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[THIRD SERIES.]

ART. XXXVI.—*On Endothermic Reactions effected by Mechanical Force;* by M. CAREY LEA. (Part First.)

IN a preceding paper the effects of pressure on the silver haloids were described. These salts were readily blackened and so gave evidence of partial reduction. That investigation was undertaken with the object of bringing into complete harmony the effects upon these haloids of the different forms of energy. It had been previously shown with respect to all the other forms of energy that a slight impression made upon the haloids caused an effect not visible to the eye but capable of indefinite increase by the application of a reducing agent. Also, it had been shown in the case of mechanical force that a slight application would cause an invisible effect which could be rendered evident by the application of a reducing agent. It seemed to follow almost necessarily that a powerful application of the same agent would bring about an effect visible to the eye. Experiment proved this to be the case.

It next appeared worth while to examine whether the same agent, mechanical force, would not be capable of bringing about analogous chemical changes in other compounds. For the nature of these changes was something quite different from anything that had been previously described. In Prof. Spring's well known investigation, combination was brought about between substances whose tendency to combine was restrained by their being in the solid form. This obstacle was removed by subjecting them to great pressure, and the same remark applies to some of the interesting experiments of Dr.

Hallock. But the reduction of the silver haloids and other reactions presently to be described involve a quite different principle. The reactions produced are all endothermic; energy is consumed in accomplishing them and this energy is supplied by mechanical force.

The combination of screw and lever affords the best means of applying pressure. A careful study as to the most suitable method of using these powers led to the selection of the vise form. It was found, however, that the manufacturers of heavy vises were unwilling to undertake to furnish vises with jaws that would sustain the force intended to be exerted on them, namely, that of a steel lever three feet long acting on a screw with six turns to the inch. I was therefore obliged to have them made under my own supervision. From a bar of tough rolled iron 4 inches wide by 1½ thick, pieces about 18 inches long were cut and were forged into shape by a blacksmith; where the jaws met they were faced with steel welded on. Suitable screws were easily obtained, but the nuts furnished with them having commonly only an inch in length would subject the thread to the danger of stripping. They were replaced with nuts 4 inches in length, thus distributing the strain over 24 turns of the thread. Two vises made in this way over a year ago have endured severe use without the least sign of strain.

With a lever having three feet in length between the center of the screw head and the end at which the force is applied acting on a screw with six turns to the inch, the multiplication of force is 1357 times. As it is easy to apply a pull of a hundred pounds or even much more, a pressure of 135,000 lbs. is easily obtained. As it was intended to keep the substances which were to be subjected to pressure from any contact that might affect them they were folded up in platinum foil and this was set in a V-shaped piece of soft sheet copper. The portion of material which received the pressure was about ½ inch long by ¼ wide; it consequently had an area of about ⅛ of a square inch. This limited surface received a pressure in the proportion of over a million pounds to the square inch or about seventy thousand atmospheres. These of course are calculated pressures subject to deduction for friction. The amount lost in this way cannot be determined but is known to be considerable.

By the aid of these means the following results were obtained. In all cases the material was wrapped in either platinum or silver, usually platinum, foil. There was no action in

any case on the metal, which preserved its full brightness in the parts in contact with the material, so that the effects observed were due to pressure only.

Silver sulphite in platinum foil was moderately darkened by two days pressure.

Silver salicylate was rendered very dark by two days pressure.

Silver carbonate was moderately darkened by a somewhat longer pressure.

Silver tartrate was not affected.

Silver oxide was thoroughly dried at 150°. A piece of platinum foil was heated to redness and rapidly cooled, a portion of oxide was folded up in it and weighed. Weight found ·7639 It was then subjected to very great pressure for four days. Weight found to be ·7639, no change.

Ferric oxide recently precipitated and dried. No effect produced by pressure, no formation of ferrous oxide.

Potassium platinobromide. Where the pressure was greatest the brilliant red color of this substance was blackened, not superficially only, but all through.

Ammonium platinochloride. Moderate but well marked darkening.

Potassium chlorate. When this substance was subjected to pressure by itself no effect whatever was produced and not a trace of chloride was formed. But when it was mixed with silver nitrate, both in fine powder, and subjected to pressure there was an evident formation of silver chloride. The material was no longer completely soluble in water but left an abundance of white flakes which darkened when exposed to light.

Mercuric oxide requires a very high pressure to produce an effect upon it. It then darkens slightly but very distinctly and this change seems to be accompanied by a slight loss of weight requiring, however, very careful weighing to detect it. The darkened part as well as the rest dissolves without difficulty in acetic acid and consisted therefore probably of traces of mercurous oxide and not metallic mercury.

Mercurous chloride showed no change.

Mercuric chloride. Corrosive sublimate perfectly free from calomel, which commercial sublimate is very apt to contain, was subjected to great pressure and then treated with ammonia. As no darkening took place there had evidently been no reduction.

Mercuric iodide. Red mercuric iodide when subjected to very great pressure darkened considerably and at points where the pressure was greatest it became absolutely black. It did

not appear however, that any iodine was set free, none could be extracted with alcohol.

Mercuric oxychloride, $2HgO, HgCl_2$; heavy pressure caused much darkening.

Sodium thiosulphate with a moderate pressure compresses to a hard translucent cake but does not undergo any decomposition.

To the foregoing cases are to be added those of the three silver haloids described in a previous paper; these blackened with a quite moderate pressure even in the case of the iodide.

Although in all these instances the darkening is well marked, still the actual proportion of material affected is small, so that in many cases it is difficult to apply tests to decide as to the precise nature of the substances formed. In some cases, however, this can be done and we are justified in concluding that many of the salts of easily reduceable metals, especially of silver, mercury and platinum, undergo reduction by pressure. Such reactions are endothermic and *it therefore follows that mechanical force can bring about reactions which require expenditure of energy, which energy is supplied by mechanical force precisely in the same way that light, heat and electricity supply energy in the endothermic changes which they bring about.*

In the second part of this paper additional support will be adduced for these conclusions.

August, 1893.

ART. XXXVII.—*Studies on the Chipola Miocene of Bainbridge, Georgia, and of Alum Bluff, Florida, with an attempt at correlation of certain Grand Gulf group beds with marine Miocene beds eastward;* by AUG. F. FOERSTE.

THE Miocene strata of Georgia, Florida and Alabama can be divided quite conveniently into three groups. Beginning with the older, these would be called in northwestern Florida, the Chattahoochee, Chipola, and Chesapeake Groups. The Chattahoochee contains an assemblage of fossils decidedly Miocene. A considerable number of forms have close affinities with those of Chipola age, while a decidedly less close relationship is found to exist with forms from the Vicksburg Eocene, at least as far as could be determined by comparison with those Vicksburg fossils actually discovered by us in southwestern Georgia. The facies of the Chipola fauna is decidedly southern, sub-tropical in fact, and there are many species iden-

tical with or closely allied to Miocene forms of regions bordering on the Caribbean Sea. The Chesapeake fauna, as its name was intended to imply, has however a decidedly northern facies, though the species are chiefly such as have long been known to exist in the South Carolina and North Carolina Miocene.

Alexander Agassiz has shown that in later Mesozoic times the Gulf of Mexico was probably connected with the Pacific across Central American regions, and the paleontological evidence favors the idea that this connection was not terminated until the close of the Eocene. The subsequent rise of the Central American ranges must have shut off a western outlet to sub-equatorial currents, and such currents as then entered the present Gulf region were obliged to find an outlet by curving along the western and northern shores until they found an exit, as does the Gulf Stream of to-day. This early Miocene return-current, however, is shown by Mr. W. H. Dall* not to have passed to the south of the peninsular portion of Florida, but to the north of it, between present peninsular Florida and Georgia. For convenience in terminology the return-current may be called the Okefenokee current, and the passage, the Okefenokee straits.

Mr. Dall* shows that towards the end of the Eocene a part of peninsular Florida had already been raised above the sea, and that during the deposition of the Nummulitic or very late Eocene beds, "this elevation (probably in the form of a chain of islands), had continued long enough for these islets to acquire a landshell fauna, as far south as about latitude 29° north." This group of islets of central Florida having a similar geological history may be conveniently termed the Ocala islands. The area occupied by these islands was increased during the earlier Miocene, and their continuous history is suggested by the presence of forms in the upper part of the Orthaulax beds, identical with those already mentioned as occurring in the late Eocene of this region. North of the Ocala islands the very wide Okefenokee passage must have been shallow at first, as is suggested by the fact that the Chattahoochee does not immediately introduce as southern a type of fauna as is contained in the later or Chipola beds, when the passage was probably deeper and the return current more vigorous. The Chipola fauna with its decidedly sub-tropical, Antillean or Caribbean facies, extended all along this passage as far as the Atlantic, and thence some distance northward.

A great deflection of currents took place at the close of the Chipola.* Instead of the eastward flowing warm water Okefenokee current, the southwestward-running Chesapeake or cold

* Correlation Papers. Neocene. See also publications of Mr. L. C. Johnson.

water current seems to have split near the northeastern part of present Florida, and while a part flowed along the eastern and southern margins of the then greatly extended Ocala islands, another part passed by way of the Okefenokee passage to the westward and permitted a cold water fauna to extend all along the southern border of the Miocene continent, almost coincident with present northern Florida, so that the two faunas Chipola and Chesapeake, though probably to a considerable extent contemporaneous, in point of time, are stratigraphically very distinct here and represent different geological ages for this southern area. How completely changed the forms of life became by this deflection of currents, can only be appreciated by one who has had the good fortune to collect along the Appalachicola and Chipola rivers.

Fossiliferous exposures of Chipola age north of the well known localities at Alum Bluff and south of Bailey's Ferry are known only at one place, half way between Bainbridge and Fowltown in Georgia and thence eastward for some distance. These localities discovered by Professor Raphael Pumpelly * are about 40 miles northeast of the Alum Bluff exposures, and represent a northing of about 22 miles across the strike. Their chief interest lies in the fact that they represent the extreme northern limit to which the Chipola current was able to penetrate; they are in fact immediate off-shore deposits. This is shown not only by the very comminuted and strongly washed and rounded shell fragments which characterize these horizons, often making their determination very difficult, but also by the presence of pulmonate land shells: an undoubted *Helix* and an apparent *Bulimulus* as indicated in the list given later.

Another point of interest consists in the fact that these fossil localities have recently been shown by the still unpublished work of Prof. Pumpelly to constitute a definite horizon in the red clay hills of the region, overlying the Chattahoochee formation which constitutes the lower portion of these hills. Now these red clay hills form a part of a great series becoming a sort of plateau in southwest Georgia and adjacent Florida, and having those lithological characteristics which would lead them to be classified as Lafayette clays, where the determination of the Lafayette is not the result of detailed work over areas not too large to prevent definite correlation. It is becoming evident in consequence of Prof. Pumpelly's stratigraphical studies that the red clay hills of this country characteristically present Chattahoochee at the base, Chipola higher up, still higher horizons representing undoubtedly the Alum Bluff sands, and whether any higher horizons are present remains to be determined.

* W. H. Dall, Correllation papers, Neocene; under *Georgia*.

The often sandy clays overlying the Chipola of this red clay hill region from Bainbridge southward are undoubtedly to a considerable extent perezonal material, becoming coarser towards the unfossiliferous Chattahoochee embayment of Chipola times. What this means will be better understood when it is learned that in Florida the Chipola also ends above in a mass of perezonal sands, the feather edge of the much thicker northern deposits. These perezonal sands, moreover at Alum Bluff, contain in places frequent impressions of palmetto and many dicotyledonous leaves, showing a great Gulfward extension of continental land before the deposition of the Chesapeake. This may account in part for the fact that while the Chipola has been found farther north, the Chesapeake can be traced only a short distance north of Alum Bluff.

Previous publications with reference to the position of the leaf remains, if correctly understood, are entirely erroneous. At Alum Bluff the Chipola rises only a few feet above the river's edge under ordinary conditions of water level. Below they consist of a strongly calcareous sandy formation, calcareous chiefly on account of its abundant shell remains; becoming a loose sand layer above as soon as the fossils practically disappear. This upper sandy portion may be almost structureless and contain a few gasteropods and oyster shells, or it may be strongly cross-bedded, when it is likely to contain trunks with more or less of the leaves of palmetto palms, or they may be finely interbedded with thin more clayey layers, when they are more apt to contain the best specimens of the dicotyledonous leaves. In the few localities studied the cross-bedded sands lie over the evenly bedded leaf layers last mentioned, and the stray oyster shells are found some distance away horizontally, at various levels. These formations all evidently form a unit and signify simply that towards the close of the Chipola a considerable area was added to the land and the effects are recognized as far south as Alum Bluff in the form of *land* plant containing deposits. (It will be remembered that earlier in this paper the writer notes the similar observation of Dall when he states that towards the upper part of the equivalent Orthaulax bed a *land* shell fauna comes in). Above these leaf-bearing sands at Alum Bluff the Chesapeake formation is found.

To every one familiar with Southern geology it is evident that Tertiary rivers here have given rise to great perezonal deposits. Stratigraphically the Altamaha grits some distance south of central Georgia and the Grand Gulf group of the Mississippi embayment should represent such perezonal deposits for the entire Miocene, since they rest directly upon the Eocene. Only recently has an attempt been made to subdivide

the Grand Gulf group and to correlate its members with the marine Miocene deposits farther east.

Mr. Lawrence C. Johnson, to whom the writer is indebted for the most of the following information,* has been enabled to divide the Grand Gulf group into four phases: A basal quartzitic phase called the Bayou Pierre phase developed chiefly towards the Mississippi river; a second, called the Fort Adams or Ellisville phase which has been traced eastward into Alabama; an upper or Hattiesburg phase, abounding in phytogene remains which has also been traced into Alabama; and a fourth or Pascagoula phase which in its eastward extension has been found only in borings in Mobile County at the southwestern corner of Alabama.

The Hattiesburg or phytogene phase is well developed in Mississippi at Rawl's Springs and the shoals of Bouie river near Hattiesburg; at Coal Bluff, near Augusta, on Leaf river; at Powe's Bluff on the Chickasawhay river, above Lakeville; at Shell Landing, below Roberts' Bluff, four miles southwest of Vernal; extending thence into Alabama, occupying the southern part of Washington County, occurring, for instance, on the southern branches of Bassett's creek, where crossed by the St. Stephens and State Line road; thence across northern Baltimore into Escambia County where the Conecuh river and its tributaries expose this phytogene phase near Castleberry on Murder creek; at Coal Bluff, seven miles south; at Silas Bluff, on the Conecuh, six miles east; and at Roberts' on Silas creek, not far eastward.

At the last locality, Roberts, occurs an exposure which seems to be of considerable importance for purposes of correlation. Here "the bluff washed out by the waste-way of the mill is filled with the casts of fossils." Mr. Johnson informs me by letter that Mr. Dall thinks these fossils indicate the lowest or oldest Miocene. "The wood and lignitic matter" or Hattiesburg phase, occurs "in the upper part of this wash-out bluff." The most northern outcrops of the Chesapeake in this vicinity seem to be at "the low shell landing on the Yellow River at Oak Grove, six miles south of the Alabama line."*

In a general way it seems to be possible therefore to establish a correlation between the Miocene of the Appalachicola embayment region, and that of the eastern margin of the Grand Gulf Group. Correlating the phytogene or Hattiesburg phase of the Grand Gulf at Roberts with the leaf-bearing sands at the top of the Chipola at Alum Bluff, the Ellisville and lower horizons of the Grand Gulf Group of this vicinity should correspond to the marine Chipola and the Chattahoo-

* Science, Feb. 17, '93, and personal correspondence.

chee formations eastward; and the Oak Grove horizon should correspond to the Chesapeake horizon of Alum Bluff at least to the extent of representing the later Miocene of this area.

Mr. Johnson in his letter mentions only Euchee Ana in Walton Co., Florida, as a more eastern phytogene locality. The connection between the Roberts phytogene locality and the Alum Bluff bed is therefore not determined by as frequent intermediate localities of that description, as could be desired. The better known course of the upper or Chesapeake Miocene must be therefore relied upon (in addition to the correlation evidence just given) to establish the continuity of the lower horizons.*

The difficulties which are at present being found to distinguish between the horizons of the more western Miocene localities will be better understood if the effects of two such different currents as the Chipola and the Chesapeake currents are considered. During the deposition of the Chattahoochee along the Appalachicola embayment, the southern current does not seem to have brought in as yet a great quantity of southern or Chipola types. From the nature of this current the fauna would be introduced into this embayment from the west, and in the western localities an intermixture of Chattahoochee and Chipola fossils might occur, while a more rapid introduction of the Chipola fauna at some *later* date into the Appalachicola region would make the change there more sudden, and the two faunas would be more distinct in this eastern embayment. At Alum Bluff the later history of the Chipola is that of a formation containing chiefly phytogene remains. During this later period of the Chipola the Chesapeake fauna was being introduced from the northeast, but owing to the phytogene phase at Alum Bluff the intermixture of Chipola and Chesapeake fossils is not shown here, and by the time that marine waters again covered Alum Bluff the southern fauna had been excluded by the Chesapeake current. Towards the west, however, this transformation of faunas *may* not have been so complete at the close of the phytogene phase, in fact

* The difference between the correlation here attempted and that suggested by Mr. Johnson, in his paper on the Miocene group of Alabama, loc cit., is that the Alum Bluff plant containing deposits being considered at that time of post-Chesapeake age, it was necessary on the basis of any true principles of correlation to classify the phytogene deposits of Alabama, if at all, as post-Chesapeake, instead of pre-Chesapeake, hence Mr. Johnson's desire to classify the fossiliferous deposits at Roberts as the Chesapeake (Alaqua phase) instead of the lowest Miocene, as he informs me Mr. Dall interprets the same. A marginal pencil note by Mr. Johnson to this passage adds "mixed with some of older time of Chipola" fossils suggesting the possibility that Chipola as well as Chattahoochee fossils may be present below the phytogene deposits of Alabama. On the basis of present views the true Chesapeake deposits of Alabama must be expected above instead of below the Hattiesburg phytogene phase. How far these views are correct will have to be shown by future studies.

the cold water current may never have been strong enough to *totally* exclude the warm water fauna so far westward, and hence an intermixture of Chipola and Chesapeake faunas with a decrease of the cold water elements must be expected on going westward beyond the sphere of strongest influence of this current. Finally, the phytogene phases being of course a fixed horizon only relatively, showing only a general concordance of continental development southward, it may be, that while the Alum Bluff region was receiving phytogene perezonal deposits, the invading Chesapeake fauna of this time, although excluded from the Alum Bluff area, passed by to the southward, and reached western areas before certain localities in this western region had assumed the phytogene phase. This would be quite naturally the case if the elevation of the Chipola land was more pronounced eastward in the Appalachicola area, than westward in the Yellow River region. The result would be the introduction of a Chesapeake element into the Chipola fauna at a time preceding the phytogene stage of these western regions. In this manner a certain commingling of Chesapeake and Chipola types might be expected to exist both in the formations preceding and in those following the phytogene phase westward. With a full understanding of all of these possibilities it may be possible to establish in the future on the basis of detailed work, some such correlation between the Miocene horizons of the Appalachicola embayment and the various members of the Grand Gulf group, as that suggested in the preceding lines, on the results of the present stage of knowledge, and in consequence partly of the discovery of the phytogene character of the upper Chipola sands at Alum Bluff. It is hoped these observations may encourage further investigation and not be considered final.

The Chesapeake formation at Alum Bluff merges at the top into a few feet of a dark looking clay, the burrowing places of thousands of mud-burrowing bees, in which clay occur Chesapeake fossils, in some places rather plentifully. While of course it would be useless to deny the total absence of phytogene remains here, since negative evidence is never final, it should be said that the writer made two trips to this region, one for the special purpose of determining this question, and while there was no trouble in tracing the loose palmetto leaf and other remains to the Upper Chipola sands and their interlaminated clays in the cliffs above, where they occur *in situ*, in no instance was any leaf or stem found by us in the peculiar dark clays which terminate the Chesapeake at this locality.

A provisional list of the Gasteropod Gully species with a comparative study of their distribution southward, as well as their history in Chattahooche and Chesapeake times.	Chattahoochee formation.	Chipola formation.				Alum Bluff, Chesapeake.	Horizons of Types.	Publications.
		Gasteropod Gully.	Alum Bluff.	Bailey's Ferry.	Okeetokse Bluff			
Ostrea divaricata, Lea, 1	?	*	?	?			Claiborne.	1
Pecten Madisonianus, Say, 2	*b*	*					Chesapeake. Older Maryland.	2
Arca idonea, Conrad	*a*	*	*	*	*	*	Chesapeake.	2
Arca, 3	*	*			?			
Cardita [Carditamera] protracta, Conrad, 4		*	*		*		Chesapeake.	2
Venus, var. of mercenaria, small, 5	*	*						
Strigilla flexuosa, Say		*			*		Chesapeake.	3
Mactra subcuneata, Conrad		*					Chesapeake.	2
Solen ensis, Linné, 6	*a*	*				*b*	Chesapeake.	3
Conus planiceps, Heilprin, 7	*a*	*	*	*	*		Chipola.	4
Drillia lunata, Lea, 8		*				*a*	Chesapeake.	
Drillia, 3 species		*						
Marginella, 9		*	?				Chipola. Chesapeake.	4
Melongena, cf. subcoronata, Heilprin, 10		*	*c*				Pleiocene.	5
Fulgur [Fulgur], 11	*c*	*						
Fulgur, cf. spiniger, var. nodulatum, Conrad, 12	*	*		*				
Latirus, 13		*						6
Nassa, 14		*						
Typhis acuticostata, Conrad, 15		*					Chesapeake.	2
Typhis gracilis, Conrad, 16		*					Claiborne.	1
Scala [Apalia], 17		*						
Turritella gatunensis, Conrad, 18	*	*	*	*	*		Miocene.	4
Turritella, cf. acropora, Dall, 19		*					Recent.	4
Turritella, cf. terebriformis (Conrad), Dall, 20	*a*	*	*	*	*	*	Miocene.	
Solarium, cf. bellastriatum, var. Vicksburgense, Dall, 21		*	*				Vicksburg.	4
Crucibulum auricula, var. imbricatum, Sowerby, 22		*						
Caliptræa centralis, Conrad	*	*					Chesapeake.	3
Crepidula fornicata, Lamarck, 23		*				*a*		
Natica [Cryptonatica] floridana, Dall	?	*	*a*	*			Chipola.	4
Chlorostoma [Omphalius] exoletum, Conrad, 24		*					Chesapeake.	4
Fissuridea, cf. Griscomi, Conrad, 25		*					Older Maryland.	2
Helix, cf. adamnis, Dall, 26		*					Chipola.	4
Bulimulus ? 27		*						
Balanus		*						

List of publications: 1. Lea. Isaac, Contributions to Geology. 2. Conrad, T. A., Fossils of the Tertiary Formations. 3. Tuomey and Holmes, Pleiocene Fossils of South Carolina. 4. Dall, W. H., Contributions to the Tertiary Fauna of Florida. 4. Heilprin, Angelo, Explorations on the West Coast of Florida. 6. Whitfield, R. P., Gasteropods of New Jersey, Monograph, U. S. G. S., 18.

While there have been already some very valuable results attained in the study of the paleontological remains of certain localities in the Gulf Miocene, chiefly due to the energy of Mr. W. H. Dall, the examination of the geology can hardly be said to have more than begun; and the present paper is offered only as one among pioneers in this direction. A list of the fossils of the Gasteropod Gully locality and of the exposures of the same horizon within a radius of two miles towards the east and southeast are here appended. Owing to the lack of opportunity for the present to complete their study by a comparison with the original types scattered in various museums, the publications used in their identification are indicated in the last column, and the appended remarks will sufficiently describe the particular forms discovered. The main value of this list however, consists in the comparison of the Gasteropod Gully specimens as types, with the corresponding or nearly related species found elsewhere in the Appalachicola embayment, and actually in the writer's possession. *a* denotes a moderate variation from the forms *typical of the Gasteropod Gully Chipola; b* denotes distinct variations, therefrom, and *c* suggests only a similar general habitus and form.

Notes on the preceding species.

1. The Chattahoochee, Alum Bluff and Bailey's Ferry specimens are decidedly of the Ostrea divaricata type, but from Gasterpod Gully only the free valve is known. 2. The three striæ along the back of the ribs are not so strong as is indicated in Conrad's figure; the Chattahoochee specimens reach only four-sevenths of the normal size and have 16 or 17 ribs. 3. Posterior ribs strongest; umbonial ridge very strongly defined posteriorly near the beak; a depressed area or groove anterior to the same near the margin, anteriorly to which with a concavely sinuous outline the breadth of the valves is diminished. 4. Anterior half strongly depressed; ribs (19 or 20) and interspaces about equal; cross striations strong and tuberculate over the anterior ribs, squamose towards the umbonial slope, and coarsely striate posteriorly; a narrow plication follows the posterior hinge line, succeeded below by a broad plication, then two narrow ones, then a broad one, after which the broader plications of the umbonial slope come in. 5. Not exceeding 45^{mm} in length; with elevated concentric ridges about 2^{mm} apart, or less regularly arranged. 6. The Chattahoochee specimens are typical, the Gasteropod Gully one is relatively broader, and those from Alum Bluff are smaller. 7. In Chattahoochee specimens 4 to 5 revolving striae ornament the whorls of the spiral. 8. Nucleus unknown; remainder $21{\cdot}5^{mm}$ long, with 7 whorls, the earlier ones more rapidly tapering, the last $7{\cdot}7^{mm}$ in diameter, with 9 ribs. 9. Form of the spire and of the posterior end of the aperture between M. ballista, Dall and M. bella, Conrad; outline of the

anterior regions nearer M. bella; length 12·5mm. 10. Spines of the shoulder usually 9, reaching 13 on a whorl, variable from short and blunt to larger and more acute, but not normally so acute or with such sharp lateral edges as in the type of M. subcoronata; the area between the angle of the shoulder and the suture is more inclined. 11. Maximum length 37mm, suture just beneath the angle of the shoulder of the preceding whorl, area anterior to the suture gently concave and then rounding into the body, the earlier whorls may be distinctly nodulose, but the nodules usually become obsolete in the last whorl. Spiral striæ present below the body, at times also visible above the rounded angle of the shoulder. The smaller shells with obsolete nodules have the general appearance of Bulbifusus. In the Chattahoochee occurs a species 45mm long, with acute spines along the shoulder, 9 or more on a whorl. 12. Spire very low, whorls keeled, suture applied on or just beneath the keel, shoulder flattish, slightly concave, keel strongly angulate, nodulose, or wavy or the last whorl without distinct tuberculation; length 28mm. 13. Canal in mature specimens strongly constricted at junction with aperture, more open in immature ones; liræ 6 to 7; plications 2, oftener obsolete; varices narrow, varying to more acute, the alternate ones almost wing-like, resembling Triton. 14. Near Nassa trivittata, Say, with about 15 ribs, crossed by coarse striations which are distinct below, obsolete on the body, and which give rise to a single series of course nodules just below the suture. 15. Spire a little less elevated. 16. Length 18mm, width 10mm; spire more rapidly tapering, varices 4, triangularly pointed but hardly spinous above, ridges running thence to the sutures above and below, and to the preceding tube. The intermediate tubes in our specimens rise so moderately above the angle of the shoulder as hardly to be more than apertures, not elongated tubes; this may be due to wear. 17. Length 17mm, width 6mm, 7 or 8 whorls below the nucleus, 12 strong ribs below, strongest posteriorly, crossed by five distinct striae between the sutures. 18. Varying towards subgrundifera, Dall, with which it is connected by intermediate forms. 19. A distinct large quite rapidly tapering species, with a strong basal (anterior) and an almost equal strong medial, rounded spiral rib, the intermediate portions strongly constricted, the whole ornamented by fine close spiral striae. 20. Very variable. 21. A fine striation between the peripheral keel and the spiral above, as well as below; in addition to the last there are below, first a narrower spiral, then four of nearly equal size, and finally the abruptly broader umbilical carina. 22. Low narrow spirally radiating ribs, becoming obsolete towards the apex, curving towards the right below, crossed obliquely by close distinct radiating striae. 23. A small form. 24. Diameter 8·5mm, spire lower, upper surface more flattened, producing a less regularly rounded periphery. 25. Length 16·8mm, width 1·2mm, height 10mm, with about 70 radiating striae at the

periphery, the striae being distant at the apex, becoming broader and close at the periphery. These are crossed by concentric striae which are about equally distant towards the apex, but close at the periphery; the result is a cancellated appearance towards the apex which disappears towards the base. 26. Diameter 7·3^{mm}, elevation 3·9^{mm}, spire very low, whorls 5, umbilicus small, open. The outer and inner lips seem to be joined over the body by a V-shaped lamina, of which all of the lower but only a portion of the upper part is preserved in the specimen. 27. Only the five upper whorls are preserved.

ART. XXXVIII.—*Mineralogical Notes;* by W. E. HIDDEN.

Transparent Xenotime, from Alexander County, North Carolina.

AT a locality about one mile southeast of Sulphur Springs, an outcropping of quartz was investigated and a "pocket" of beautiful crystals was opened up. As there was much muscovite associated with the quartz crystals, and in a very disintegrated condition, the whole vein matter was hauled to water and washed after the manner of gold washing, that is to say, in a "rocker." The final concentrates proved to be rich in brilliantly clear monazite and to contain a few small crystals of clear, bright xenotime. The best of these, which were unfortunately the very smallest, were sent to Prof. Penfield for careful measurement of their angles. He states his results as follows: The xenotime crystals gave very good inflections but showed some variation in angles. The best crystal gave the following:

	North Carolina. Measured.	Dana's 6th Edition. Calculated.
$z \wedge z''$,	$111 \wedge \bar{1}\bar{1}1 = 82°\ 18'$	$82°\ 22'$
$z \wedge z'$,	$111 \wedge \bar{1}11 = 55\ \ 26\frac{1}{2}$	$55\ \ 30$

He also measured $z \wedge z'' = 82°\ 19'$ and $82°\ 21\frac{1}{2}'$ on two other crystals.

It is thus seen that the measurements of these new crystals do not vary essentially from those of vom Rath and Klein quoted by Dana. They present the prism *m*, 110, in combination with the pyramid *z*, 111, and a steeper pyramid which is probably *u*, 331; like figures 3 and 4 on p. 483 of Dana's Mineralogy, sixth edition. The color of the crystals was clear yellow-brown. The largest one was only 3 × 11 mm., while those measured were only about 1 × 2 mm. A distinctly twisted gyroidal-like development was positively noticed in the larger crystals. It was impossible to obtain enough of these rare crystals for even an approximate analysis.

Jarosite, from the Jarilla Mts., Doña Ana Co., New Mexico.

On the "Shoo-ah-me" (the Peublo Indian name for turquois) Mining Claim, situated in the Silver Hills District in the above described region, there are several outcrops of limonite, which at no great depths, change to pyritiferous copper ore. At one of these the crystals of jarosite here referred to, were found in comparative abundance though small and unsatisfactory. Prof. Penfield kindly tested some of them and found them to contain Fe_2O_3, SO_3, H_2O and K_2O, but none were found smooth enough for measurments. The forms presented were apparently *c*, 0001; *r*, $10\bar{1}1$ and *s*, $02\bar{2}1$. They occur as druses of bright brown crystals having curved faces. It is interesting to add that a fine quality of turquois was being mined less than three rods from where the jarosite was found.

Green Xenotime, from the Brindletown Gold district of Burke County, North Carolina.

This variety of xenotime occurs as a rare constituent of the auriferous gravels of the region named. It has not as yet been found there *in situ*. The common condition is that of opaque rough crystals, having quite perfect prismatic cleavage, of a gray-brown color and a low degree of hardness. Rarely, the crystals exceed a gram in weight and exceptionally some of quite perfect form over two centimeters in diameter have been found. Even larger groupings, of a polysynthetic character, have been found near the head of Brindle Creek on the land belonging to J. C. Mills just opposite Pilot Mountain.

It was in the interior of some of the larger crystals that the new green variety was found. From its irregular position, within the brown opaque crystals, it seems evident that the green portion represents the original condition and the brown is an alteration product, due to hydration, oxidation, etc. The new material, which is of a bottle-green shade, is transparent to translucent and has a bright vitreous luster. When finely pulverized *it is soluble in hot hydrochloric acid*, which feature is new to the species. It goes readily into solution (excepting the SiO_2) when boiled with concentrated sulphuric acid in platinum and to the resulting paste sufficient water is added.

Through the kindness of Prof. F. W. Clarke, of the U. S. Geol. Survey, I am enabled to add here analyses by Mr. L. G. Eakins, of both the green xenotime and of the brown alteration product. In conjunction with these an analysis by Blomstrand of a similar xenotime found at Narestö in Norway* is added for sake of comparison.

* See Dana's System Min, 6th edition, p. 749.

	No. 1. *Green.* Eakins.	No. 2. *Brown.* Eakins.	No. 3. Narestö. Blomstrand.
SiO_2	3·46	3·56	2·36
ZrO_2	1·95	2·19	1·11
UO_2	4·13	1·73	----
UO_3	----	----	3·48
SnO_2	----	----	0·08
ThO_2	tr.	tr.	2·43
PbO	----	----	0·68
MgO	----	----	0·26
Al_2O_3	0·77	1·57	0·28
Fe_2O_3	0·65	2·79	2·01
Ce_2O_3	----	----	0·96
$(La, Di)_2O_3$	0·93	0·77	----
Y_2O_3	56·81*	55·43*	30·23
Er_2O_3			24·34
CaO	0·21	0·19	1·09
P_2O_5	30·31	29·78	29·23
F	0·06	0·56	----
H_2O	0·57	1·49	1·77
	99·85	100·06	100·31
Less O for F		0·23	
		99·83	
Sp. grav. =	4·68 at 24·2° C.	4·46 at 24·4° C.	4·49

The material analyzed by Eakins in both instances, was selected with great care by the use of a lens and was *apparently* more uniform in quality than the analyses would seem to indicate. It is a matter of surprise that the analyses, especially that of the green variety, show so complex a mixture. Calculation shows that, the molecular ratios of the P_2O_5: $(Y, Er)_2O_3$ group is as 21·34 : 21·85 and we therefore must conclude that the SiO_2 is present, not as admixed quartz, but as an essential acidic element in combination with the other constituents: the P_2O_5 being alone *insufficient* for even the $(Y, Er)_2O_3$ group.

The analysis of the green material may prove a composition due to a partial alteration in the nature of pseudomorphism by gradual substitution, but it seems probable that xenotime† is either in truth, at times, a silico-phosphate, like some monazite and auerlite; or it is often mechanically mixed with some

* The Y Er group includes any scandium present and in both cases has a molecular weight = 260 (Eakins).

† Prof. Penfield has lately shown by his analysis of a Colorado xenotime, found *in situ*, that it does sometimes occur in nature in a condition of almost normal purity. See vol. xlv, p. 398, May, 1893.

cyrtolite (in infinitely fine crystals) and also other silicates of the rare earths. The UO_2 found by Eakins, like the UO_2 found by Blomstrand in the Narestö xenotime, is probably to be regarded as an isomorphous replacement of thoria. The green color would seem to indicate that the UO_2 was present as a phosphate. The ThO_2 is not constant even in the same locality, for some of the common xenotime from this same region, tested *for thoria alone* proved to contain over four per cent.* Another trial on new material gave 2·36 per cent ThO_2. The fluorine, it will be noticed, is *richest* in the brown variety (only a mere trace in the green) which is also the most hydrated and richest also in alumina and ferric iron. Prof. Henry A. Rowland, of the Johns Hopkins University, examined spectrographically some of this Brindletown xenotime, several years ago, and reported it to be uncommonly rich in scandium; even more so than the South Carolina polycrase.

ART. XXXIX.—*Conditions of Appalachian Faulting;* by BAILEY WILLIS and C. WILLARD HAYES, Appalachian Division U. S. Geological Survey.

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CHAMBERLIN in 1882 suggested that folding and faulting of strata in narrow zones of great sedimentation might be due to the mechanical condition produced in deeply buried layers, which would be bent initially beneath the mass laid upon them before compression produced greater deformation.† Geologists of the Appalachian division of the U. S. Geological Survey, approaching the problems of structural geology through field study in the belt from Pennsylvania to Alabama and experiments on stratified blocks, which were compressed under shot, were led independently to the conclusion that the condition which determined folding and faulting resided in the strata folded or faulted and was a mechanical condition determined by the frangibility, flexibility or plasticity of the strata and by their attitude as struts toward pressure. The experimental work and some observed facts bearing on the conclusions are described in an article now in press,‡ and

* As the thoria was separated by repeated hyposulphite treatments in a neutral HCl solution and precipitated finally as oxalate and as the ignited oxide was pure white, there can be no doubt of its identity.

† Geology of Wisconsin, vol. 1, p. 76.

‡ Mechanics of Appalachian Structure, Bailey Willis, XIIIth Ann. Report U. S. G. S.

the conditions which gave rise to the great system of overthrusts in the Appalachian province are there discussed.

But the article by Dr. E. A. Smith in this Journal for April, 1893, on Underthrust Folds and Faults, suggests the desirability of briefly presenting our views through the same medium. If the normal Appalachian overthrusts and the so-called "underthrusts" are produced by the same mechanical forces slightly modified by local conditions it seems unnecessary as well as undesirable to create a new species for the latter in the systematic classification of Appalachian structural forms.

First will be stated the antecedent conditions for the development of Appalachian structure; second, the mechanics of stepfolds and thrust-faults and repeated parallel folds or faults; third, application of the theoretical conclusions will be made to the actually observed Appalachian structure, and finally the direction from which the compressing force acted will be briefly discussed.

Sedimentation and initial dips.—The source of the greater part of Paleozoic sediments of the central and southern Appalachians is generally assumed to be a continental area lying east and southeast of the interior area of deposition. This was doubtless the original source of the material but the later formations are probably largely made up of re-deposited material eroded from those earlier formed. From the observed processes of sedimentation it is known that mechanical sediment from the land is deposited over a zone parallel to the shore and extending to a greater or less distance out to sea. But under the usual conditions of tides and undertow the greatest thickness of the deposit will be in a narrow belt along shore and will gradually lessen seaward. Throughout great masses of sediment it is frequently observed that the layers bear the rippled marked surfaces formed in shallow water, compelling the conclusion that subsidence went on at a rate equal to that of deposition. The subsidence is an argument for isostatic adjustment to shifting load. It is also an argument, on the assumption of a general cause of subsidence other than isostasy, that the effects of such cause may be localized and the subsidence accelerated by loading. Or it might be argued that any force acting vertically may deepen the water and that off shore currents expanding in deeper water and therefore slowing there would deposit heavily upon the subsiding area. Whatever view be taken of the process the fact remains that subsidence has frequently gone on at a rate approximately equal to that of accumulation of strata. The cross section of such a deposit is that of a bi-convex lens. One edge rests against the shore from which it thickens rapidly and then thins gradually seaward. The lower surface of this lens is

the conformable contact between the newer and older strata and it follows that the older strata dip more or less steeply from the shoreward side to the thickest part of the lense and thence rise more gradually seaward. The condition then existing is represented in fig. 1, and the broad shallow trough formed by the deeper strata may be called an original syncline.

FIG. 1.—Syncline of Deposition.

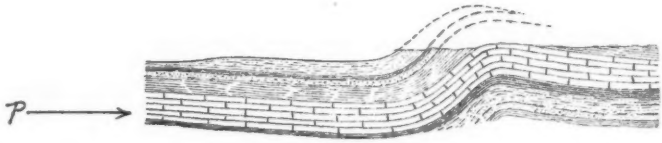


FIG. 2.—Step fold.

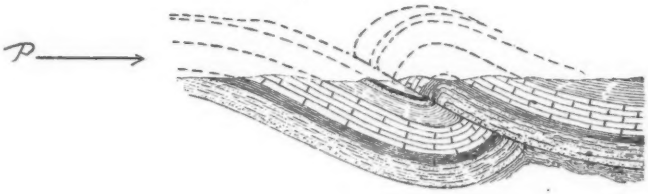


FIG. 3.—Thrust fault.

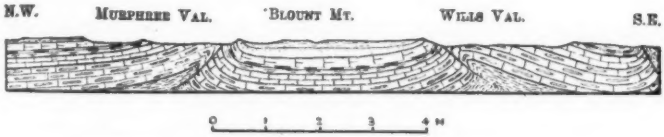


FIG. 4.—Section in Northern Alabama.

That such original synclines of deposition existed in the paleozoic strata of the Appalachians previous to compression is clearly shown from a consideration of the variations in thick-

ness of strata deposited on the great limestone. Thus in Lycoming county, Pennsylvania, the total thickness of strata between the coal measures, XIII, and the Cambro-Silurian limestone is 9700 feet, while in Carbon county it is 23,700 feet. There can be no doubt that the surface on which the coal beds formed was essentially horizontal and it follows that to accommodate this greater thickness beneath a horizontal datum and above the great limestone the latter must have had an *initial dip* from Lycoming to Carbon county. This dip amounted to about 200 feet per mile and carried the limestone down 14,000 feet lower in the Anthracite region than in the Alleghany region. It was a dip due to vertical subsidence, not to compression, and formed the northwestern gentle slope of an original syncline of deposition.

The stratigraphic sections published by the Second Geological Survey of Pennsylvania when compared in detail indicate that each of the anthracite basins is related to an area of maximum deposition in consequence of which the deeper strata assumed the form of an original syncline which later become a syncline of compression. Thus in the Wyoming basin No. XI has a thickness of 150 to 400 feet along the sides but is 1200 feet thick at Shickshinny on the synclinal axis.

In East Tennessee similar original synclines of deposition have been observed, as that in the Bays Mountains where the Silurian shales increase in thickness from 1800 feet on the western side to 4000 or more near the axis, necessitating a very considerable initial dip. Another is represented in fig. 1, p. 259, in which the thicknesses are those observed in a section through Clinch Mountain near Rogersville, Tennessee, but the position of the shore line and the shoreward thinning of the upper strata are hypothetical. In northwest Georgia the increase in thickness by 2000 feet or more in the lower Carboniferous must have produced an original syncline in the present Armuchee basin. Also on the western side of Murphree Valley in Alabama the Lookout sandstone forming the base of the Coal measures is only about 60 feet thick while 15 miles eastward it has a thickness of from 600 to 800 feet, indicating a sharp syncline of deposition on the line of the present Blount Mountain syncline. The effect of this initial eastward dip upon the structure will be indicated later.

The original synclines so far mentioned have axes parallel with the general trend of the present axes of compression which they doubtless determined, but in northern Georgia and Alabama there is evidence of an old shore line extending nearly east and west with the accompanying syncline of deposition parallel to it on the north. This has doubtless been the

chief factor in producing many of the peculiar structural features which characterize this region.*

Considered with reference to their massiveness, strata in the Appalachian province fall into three great groups: at the base a series of thinly stratified Cambrian sandstones, shales and limestones; in the middle a very massive Cambro-Silurian limestone, and on top a series of thinly stratified sandstones and shales. Locally, strata in the upper and lower series become massive but none have the extent, uniformity and massiveness of the great limestone, which is 2500 to 6000 feet thick in the folded zone and covers more than 600,000 square miles. On any line across the zone of deformation this stratum would most efficiently transmit a pressure acting tangentially to the earth's surface, and if before compression it were anywhere bent upward or downward, then during compression the preëxisting bend would determine the point at which it would yield to sufficient force; it would act as a crooked strut.

That such bends did exist in the great limestone, before the action of compression which produced the Appalachian folds, has been shown from a consideration of the process of sedimentation and from the observed synclines of deposition mentioned above. In the Appalachian province in such original synclines the steeper seaward dip was northwestward and the gentler shoreward dip was southeastward. Now if strata occupying the initial position represented in fig. 1, p. 259, be subjected to a sufficient compressive force they will yield at the bends; the original anticline, and the original syncline will be exaggerated while the steeper and hence shorter limb of the syncline will occupy the position of an arm between the forces of a couple. It will therefore be rotated so that the original seaward dip will grow steeper and, if compression continues long enough, may be overturned. Such a fold may be compared to a step of broad tread and moderate rise and hence may be called a *stepfold*, fig. 2, p. 259. This has long been recognized as the usual antecedent of an Appalachian thrust-fault.

Development of Thrust-faults.—There are three mechanical conditions by either one of which a thrust-fault may develop from a stepfold. The pressure tending to exaggerate the fold will be most efficiently transmitted by the most massive stratum, in the Appalachians by the great Silurian limestone, and any condition which weakens this stratum may lead to a fault.

The first condition is erosion. The development of folds is probably gradual, and although the original position may be submarine the rise of an anticline will eventually lift its crest

* The Overthrust Faults of the Southern Appalachians, C. W. Hayes; Bull. Geol. Soc. Am., vol. ii, pp. 141–152.

above the not very deep waters along shore. From the beginning of emergence the arch will be subject to degradation and its waste will be deposited in the adjacent synclines. Then, the crown of the arch being removed, the separated limbs of any rigid stratum will tend to approach if compression continues. If the stratum dips steeply the horizontal component of this movement will be small and the vertical component will be masked by erosion; but if the dip be gentle the rigid stratum, to which no resistance save friction is opposed, may advance over the eroded surface and a thrust-fault be developed on a horizontal or gently dipping plane. Such a thrust-fault might readily escape observation if one end of the rigid stratum were pushed upon the other or might be mistaken for an unconformity by deposition if it were exposed at the contact of younger with older strata.

The second condition, which may lead to the development of a thrust-fault from a stepfold, is fracture. If a rigid stratum be sufficiently bent, in the absence of a load adequate to cause continued flexure, the stratum will break and the crack will offer a plane of weakness on which a thrust-fault may occur. Fig. 3, p. 259. The crack will be radial to the curve and the fault being determined by the resistance offered by the gently dipping limb of the adjacent anticline, will usually have a fault-dip parallel to the dip of that limb. This is the common type of Appalachian thrust-faults. The essential condition, that the rigid stratum should be free from excessive load, may arise either because the deposits over that stratum were never very thick or because erosion cuts away overlying strata on the crown of the arch and thus removes the load. The great Silurian limestone in the Appalachian district of thrust-faults bore from 2500 to 10,000 feet of strata; and in the district of folding without the development of faults it bore from 10,000 to 30,000 feet of strata. To depths of five miles in the earth the pressure due to gravity is approximately proportioned to the depth and one foot of strata corresponds to about $1\frac{1}{8}$ pounds of pressure per square inch. Hence we infer that the great limestone broke and thrust-faults were produced under loads of 2800 to 11,000 pounds per square inch, but it folded without breaking under loads of 11,000 to 34,000 pounds per square inch.

The third condition, under which a thrust-fault may develop from a stepfold is that of plastic flow. A sufficiently loaded stratum may be stretched in its overturned limb and so thinned or torn apart as to constitute an overthrust. This type can develop only under excessive load. It is not known in the Appalachians except in the case of coal beds of the Anthracite

region and has been most fully described by Heim from examples observed in the Alps.

This explanation of the origin of stepfolds rests upon conditions of sedimentation along shore and may suffice for those cases in which the observed facts of stratigraphy indicate the antecedent development of a syncline of deposition. But geologists familiar with the number and relations of Appalachian folds and thrust-faults may fairly object to the assumption of a shore line and an original syncline for each one. A supplementary explanation is required and it must account for the extraordinary parallelism generally existing among the axes. This explanation may be found in the results of the development of competent anticlines.

Competent structure.—When a force tangential to the earth's surface affects a stratified mass, it is transmitted by the strata in the direction of their lateral extent and by each stratum according to its rigidity. To illustrate, if pressure be applied to the side of a pile of tissue paper in which are leaves of card board of the same size, the predominant effective pressure apparent on the other side is that transmitted by the cardboards. The stratum which thus most effectively transmits pressure may be called the competent stratum; and it is plain that the term "competent" is significant of relative rigidity, not of an absolute quality. In the Appalachian province *the* competent stratum was the great limestone.

If the pressure transmitted by a competent stratum arrives at a bend due to initial dip, the force is resolved into two components; the one acts in the direction of the stratification, the other acts in a line normal to the stratum, or radially. If the curve be convex upward it will develop into an anticline of deformation when the radial component of the force is strong enough to bend the strata and carry up the superincumbent load. The strength of this component is determined by the strength of the original force and by the initial curvature of the stratum. No anticline can develop unless the radial component of the force for a given original curvature is equal to the task, nor for a given force unless the original curvature is sufficient to deflect a competent component. If these conditions be fulfilled the competent stratum will rise in anticlinal form and will carry the overlying load on its crown. The zone beneath the crown is then relieved of load, which is transferred to the limbs.*

If the stratified series be made up of many beds of nearly equal competency alternating with relatively incompetent beds such as thin interbedded limestones and shales, then each com-

* H. Schardt, Bull. de la Société Vaudoise des Sci. Nat, vol. xx, 1884. pp. 143–146. B. Willis, Mechanics of App. Structure, XIIIth Ann. Rep. U. S. G. S.

petent layer will carry up the immediately overlying incompetent layer and the total weight raised in the anticline upon its numerous competent arches will be distributed through their limbs to many points of support. But if the stratified series consists of one massive competent stratum overlaid by a great thickness of relatively incompetent strata, then the total weight raised on the anticline will be transferred by the massive competent stratum to those parts of the curve which are concave upward, that is to the adjacent synclines. Applying these general conclusions to the special case of an original Appalachian stepfold we may represent (fig. 5) the competent

FIG. 5.—Development of original competent anticline A.

stratum by a single heavy black line. If the weight raised by the competent anticline A be W, then the limbs of the arch will transmit the weights w' and w'' whose sum will be equal to W and whose ratio will depend on the relative dips of the two limbs. As the limb A S becomes steeper w' will increase in proportion to w'' and its effect will be concentrated at the foot of A S. If the arch A be eroded such part of the sediment as falls in the syncline S will also concentrate in a narrow zone, while that which falls on the other limb will be distributed on its gentle slope. The downward pressure thus produced beneath the original syncline S, is directly related to W; it is an indeterminate weight which may be designated x (fig. 6).

FIG. 6.—Development of consequent competent anticline A'.

The weight x tends to depress the limb SA' and if it causes depression at S it must displace the subjacent support, which will move toward A, the region of relief; the limb S A' of the competent stratum will then sink downward in a long gentle curve. x must be greater than the weight required to displace the support at S and the excess will be exerted in bending S A'; being effective at a point A' so far distant

from S that the moment of x into S A′ is greater than the resistance which the competent stratum opposes to bending.

Now the force of compression, P, is resolved at A′ into two sets of components, those tangential and those radial to the curve. As the curvature increases through the effect of the moment $x \times$S A′, the radial components increase in proportion to the tangential and when their upward directed force exceeds the weight on the competent stratum at A′, a competent anticline will develop there.

The anticline A′ is subsequent in time and causally related to the anticline A. A′ is therefore a consequent to A and may be called a *consequent fold* in distinction from A, the original fold. The distance of A′ from A is determined by the length of the limb SA′, which is itself determined by conditions in the strata; therefore so long as the stratigraphic series remains invariable the distance A′ A will be constant and the two folds will be parallel. This is the condition which any explanation of Appalachian folding must satisfy.

The form of the anticline A′ will probably vary in different cases: it may be symmetrical or unsymmetrical, and if the latter, it may be overthrown to one side or the other. With a steep initial dip from A′ toward S, there might be developed an overturned limb facing the original fold (fig. 7) and then, if both the original and the consequent folds were faulted the thrust-faults would present opposite fault-dips. This however

FIG. 7.—Development of opposed overturns.

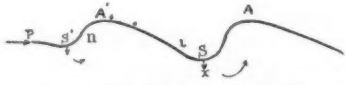


FIG. 8.—Development of parallel overturns.

is the rare exception and the reason for the overturn of the consequent in the same direction as the original fold appears from a further analysis of the process. The form of the gently sloping arm of the syncline S A′ is determined largely by the depression of S and is slightly convex upward from A′ to a point of inflexion, i, near S, (fig. 6). Now the force P is continuously resolved upon the curve A′ i into components acting tangentially along the stratification and radially at right angles to the same. The tangential components are opposed by the resistance at S while the radial components tend to lift the curved limb A′ i against the weight of the overlying strata and the resistance to bending. In the flat lying strata on the other side of A′ the force P is not resolved into components so that the only force tending to elevate this part of the competent stratum is the radial component at A′. This elevation is opposed by the weight of the superincumbent load and the

resistance to bending offered by the strata, both of which forces tend to hold down this portion of the competent stratum. But the radial components directed upward in the convex curve at and near A′ must carry up the crown of the arch, if it develops as a competent structure, and in so doing they cause the beginning of a concave curve in the section PA′. As this curve becomes sharper, the force P is resolved into components tangential and radial to the curve, the latter being directed downward. Thus the limb S′A′, fig. 8, occupies a position between forces acting downward at one end and upward at the other and a neutral point n becomes a center of rotation for that limb. Moreover the force P is absorbed in the development of these radial components and with increasing curvature there is decreasing pressure in the other limb A′S and consequently less and less tendency to further bending. The flow of material from the point of support S′ of the competent arch toward the zone of relief A′ beneath the arch also tends to promote the rotation of A′S′. Thus a consequent stepfold is developed parallel to and overturned in the same direction as the original fold which depended upon initial dips. The same process may continue with the formation of an indefinite number of parallel folds all turned in the same direction and each consequent upon the one next preceding it in time and position.

Another factor in determining the direction of overturn of the consequent fold, as pointed out by Dutton,* may be deep seated isostatic flow. If such flow of material from the area of sedimentation toward the area of erosion actually takes place its effect may be to displace S and S′, the supports of the anticlinal arches, toward the shore line and so to add to the rotation of the seaward limbs of the anticlines.

Next to the parallelism and continuity of their axes the most remarkable feature of the Appalachian folds is the uniformity in the direction of their steeper sides. This indicates a corresponding uniformity in the initial dips of the synclines of deposition which determined the form of the original stepfolds. It also indicates the prevalence of conditions favorable for the westward overturn of the consequent folds. As shown in the above analysis of the process by which the consequent folds are formed, an important condition is the long western limb of the original syncline convex upward and with gentle dip eastward.

Two exceptions to this westward inclination of the folds are known in the southern part of the province. These are the northern portions of the Wills Valley and Murphree Valley

* On some of the greater problems of Physical Geology, C. E. Dutton, Bull. Phil. Soc. Washington, vol. xi, 1889, p. 60.

anticlines The former is overturned eastward and the latter is overturned and faulted, the plane of the thrust-fault dipping steeply toward the west. The latter case is the one mentioned by Dr. Smith as illustrating his type of so-called "underthrust faults." The structure is shown in the sections accompanying the Gadsden Atlas Sheet.*

Comparing the thickness of the Carboniferous formations of this region we are able to reconstruct the original syncline of deposition which has determined the location and form of the Murphree Valley fold. In other parts of this region there is a very gradual westward thinning observable in all the Paleozoic formations implying, if any, very moderate eastward initial dips. In this particular locality, however, the Lookout sandstone, the lower portion of the coal measures, has its maximum thickness of 800 feet in the Blount Mountain syncline; from this it thins rapidly westward to 60 feet or less west of the Murphree Valley anticline and also eastward, though less rapidly to Chandler Mountain. Hence there must have been an original syncline of deposition whose axis coincided with the Blount Mountain syncline and which had initial dips eastward steeper than those westward. These initial eastward dips were sufficiently pronounced to produce an overturn toward the southeast. The form of the fold naturally determined the dip of the thrust-fault when faulting was developed as a secondary effect of continued compression.

Since the Murphree Valley fold shows a further stage of development than the southern portion of the Wills Valley fold it may perhaps properly be regarded as an original step-fold developed on the westward side of the syncline of deposition while the latter is the consequent fold.

The reason for the eastward overturn in the second case mentioned, the northern end of Wills Valley, is more obscure than in the case of Murphree Valley. The form of the fold is shown on the Stevenson Sheet† It is quite possible that the coal measures thicken eastward from Fox Mountain toward the Lookout Mountain syncline, indicating an initial eastward dip sufficient to determine the direction of overturn of the resulting fold. Whatever may have been the cause of the abnormal form which the fold assumed it was purely local, for the fold becomes symmetrical a few miles from its northern end and thence southward assumes the normal form with overturn toward the west.

Direction of the compressing force.—Thus far the origin and direction of a force adequate to produce folding and fault-

* Geologic Atlas of the United States, Gadsden Folio, Geology by C. W. Hayes. In press.

† Geologic Atlas of the United States, Stevenson Folio, Geology by C. W. Hayes. In press.

ing have not been considered in presenting the mechanics of the problems; although it is too large a subject for full discussion here it cannot be altogether omitted. It has long been assumed that the force in the Appalachian province came from the southeast, because the folds are overthrown toward the northwest. Heim disposed of this argument in pointing out that the overturn must always be toward the deeper syncline; and it is here shown that, in accordance with the conditions of deposition, the deeper syncline in original folds must be off the land. Therefore the direction of the force cannot be inferred from the direction of the overturn.

Force and resistance must be equal or movement ensues. Acting against flat strata, a sufficient pressure must be opposed by a sufficiently resistant buttress or the strata must move forward. A continental mass of crystalline rocks might constitute such a buttress and flat strata pressed against it might remain in static equilibrium so long as pressure and resistance were not strong enough to crush them. If the pressure were a growing one and the resisting buttress were firmer than the strata, then they must eventually yield either by crushing or bending. Observation shows that the latter is the common result and the lines of flexure are determined by preëxisting deflections from a horizontal attitude. When anticlines begin to develop as competent structures the force is exerted against the load upon the rising arch and the resistance is correspondingly diminished. Hence it follows that strata between a growing force and a resistant mass are subjected uniformly if at all to compression which is equal in opposite directions. Therefore, in the Appalachians the compressing force was directed both northwestward and southeastward. But from the time folding begins there will be movement from the force toward the resistance. This movement we conceive to have been in the Appalachians a superficial flow of a broad zone from northwest to southeast, from the sea toward the land. In the development of thrust-faults the *relative* movement at the surface was determined by the direction of fault-dips which depended in turn upon the direction of overturn in the original and consequent stepfolds; these are generally overturned to the northwest, and the apparent direction of the pressure is thus the opposite of the real direction. If we consider the mass above a thrust-fault as stationary, the faults are all *underthrusts*; or if we consider the motion with reference to the mass below the fault plane, they are all *overthrusts*.

ART. XL.—*On the Double Halides of Antimony with Rubidium;* by H. L. WHEELER

THE investigations of the double halides of antimony and rubidium have hitherto been confined to the chlorides, and the following salts have been described:

1 : 1	Rubidium	Antimony	Chloride,	$RbCl . SbCl_3$
5 : 3	"	"	"	$5RbCl . 3SbCl_3$
23 : 10	"	"	"	$23RbCl . 10SbCl_3$
6 : 1	"	"	"	$6RbCl . SbCl_3$

The first three of these compounds were described by Remsen and Saunders.* These investigators, after a careful study of the subject came to the conclusion that the salt $6RbCl . SbCl_3$ described by Godeffroy† does not exist.

It has been shown by the author of the present article that the 3 : 2 type of double salts is probably the only one formed by the combination of the arsenic halides with those of cæsium and rubidium.‡ Moreover, since this type was observed by Schæffer§ in the case of the double halides of antimony with sodium, potassium, and ammonium, and, since Remsen and Saunders obtained the salt $3CsCl . 2SbCl_3$ it seemed probable that this type of double halides would exist with rubidium and antimony. A thorough re-examination of the chlorides has therefore been undertaken and the investigation has been extended to the bromides and iodides. As a result of this investigation the following compounds have been obtained:

$RbCl . 2SbCl_3 . H_2O$		
$RbCl . SbCl_3$.		
$3RbCl . 2SbCl_3$.	$3RbBr . 2SbBr_3$	$3RbI . 2SbI_3$
$23RbCl . 10SbCl_3$ (?)	$23RbBr . 10SbBr_3$ (?)	

The first chloride. $RbCl . 2SbCl_3 . H_2O$, is a new type of antimony rubidium halides, which Remsen and Saunders did not obtain. The second, 1 : 1, confirms the results of these investigators, while the series of 3 : 2 salts, which includes a chloride, bromide, and iodide, corresponds to the type expected from analogy. The difference between the percentage composition required for the 3 : 2 chloride and that required for the 5 : 3 formula of Remsen and Saunders is small, and it is to be noticed that these authors do not consider their formula as definitely established. They say, "The analytical results obtained from different samples varied considerably and it does

* Am. Chem. Jour., xiv, 155.
‡ This Journal, III, xlvi, 88.
† Berichte, viii, 9.
§ Pogg. Ann., cix, 611.

not appear possible to obtain the salt in pure condition." It will be noticed that most of the analyses of the 3 : 2 chloride, made in the present investigation, show a composition intermediate between what is required for the formulas of the 3 : 2 and the 5 : 3 salts, but the bromide and the iodide were readily obtained in pure condition and gave analytical results closely corresponding to the 3 : 2 formula. Moreover the chloride, bromide and iodide just mentioned are all hexagonal and may be referred to axes which correspond closely to those of the 3 : 2 arsenic compounds. The chloride and bromide with a complex composition (23 : 10 ?) confirm the results of Remsen and Saunders on the chloride. The formula suggested by them has been retained, subject to uncertainty. It will be seen beyond that, as Remsen and Saunders have noticed, the ratio 16 : 7 corresponds very closely to the analyses, and it may be added that the ratios 9 : 4 and 7 : 3 differ so little from the other two that it would be very difficult to distinguish between any of these ratios by analysis.

For the preparation of the double halides the constituents were mixed in the presence of the corresponding dilute acids. In the case of the chlorides a 10 per cent acid was used. The mixtures were then evaporated until crystals separated on cooling. Further details will be given with the descriptions of the salts. In the case of each salt several crops were prepared and analyzed, and an attempt has been made to determine approximately the limits of the conditions under which these double halides are formed. It may be added that the analytical results are not selected, for with the exception of two antimony determinations, where an error had been detected, every determination that was made has been given.

Method of Analysis.

The salts were removed from the mother liquor, and, after pressing on smooth filter paper, were dried in the air for a short time. Portions of a little less than one-half a gram were taken for analysis. In order to determine the halogens, silver nitrate was added to a solution of the substance in water containing a little tartaric and nitric acids, the mixture was then warmed on the water bath for a couple of hours and finally, after standing twelve hours, the silver halide was collected, ignited and weighed in a Gooch crucible in the usual manner. The determination of the antimony and rubidium was effected in a separate sample. In order to do this, the salts were dissolved in a little dilute hydrochloric acid and the solutions were diluted with boiling water. Hydrogen sulphide

was then used to precipitate the antimony and, when the solutions had cooled, the resulting sulphide was filtered on asbestos in a Gooch crucible, washed with water and alcohol and then heated to 230° in an oven filled with carbonic acid. On cooling, the sulphide was weighed as Sb_2S_3. The rubidium was determined by evaporating the filtrate from the antimony sulphide to dryness with an excess of sulphuric acid, the residue was then converted into normal sulphate by ignition in a stream of air containing ammonia. The atomic weights used in the calculation of results were the following:

Cl, 35·5; Br, 80; I, 127; Sb, 120; Rb, 85·5

The Double Chlorides.

The crystals of the double chlorides are colorless, with the exception of the salt $3RbCl.2SbCl_3$; this salt has a pale yellow color exactly similar to the salts $3RbCl.2AsCl_3$ and $3CsCl.2AsCl_3$. The stability of the double chlorides, on exposure, appears to vary inversely with the quantity of antimony chloride which they contain.

1:2 Rubidium Antimony Chloride, $RbCl.2SbCl_3.H_2O$.—This new salt was obtained from hydrochloric acid solution when the constituents were mixed in the proportion of ten, eight or six molecules of $SbCl_3$ to one of RbCl. On concentrating these mixtures supersaturated solutions were obtained which sometimes remained for days without giving crystals, but on shaking or stirring with a glass rod the crystallization was induced. The crystals separate in the form of elongated, colorless, monoclinic tables. Analysis of different crops gave:

	From solutions of $10SbCl_3$ to 1RbCl.			From solution of $8SbCl_3$ to 1RbCl.	From solution of $6SbCl_3$ to 1RbCl.	Calculated for $RbCl.2SbCl_3.H_2O$.
Rb	14·61	14·71	14·74	14·64	15·07	14·44
Sb	40·75	40·97	41·09	41·07	40·97	40·54
Cl	41·83	41·53	41·11			41·98
H_2O	3·20	3·10	3·18	3·08		3·04

The crystals of this salt have a brilliant luster when first removed from the mother liquor, but on exposure they soon lose their luster, becoming opaque and decomposing. In the preparation of this salt for analysis the crystals were crushed and thoroughly pressed on filter paper, and when it was certain that the powder did not contain any mechanically mixed water, it was placed in a weighing tube. This salt is readily dis-

tinguished from the other colorless double halides of rubidium and antimony by the fact that it melts at 77°.

1:1 Rubidium Antimony Chloride, $RbCl.SbCl_3$. — This salt was first described by Remsen and Saunders;* they say that "if the excess of antimony chloride . . . be *very* great, a colorless salt crystallizing in elongated, apparently orthorhombic, crystals is obtained." I have found that by mixing the constituents in hydrochloric acid solutions, in the proportion of four or three molecules of $SbCl_3$ to one of RbCl, crystals of similar appearance were obtained. The solutions require a considerable degree of concentration and the mother liquor is more or less syrupy, hence the rubidium determinations came low and the antimony high. Analysis gave:

	From solution of $4SbCl_3$ to 1RbCl.	From solution of $3SbCl_3$ to 1RbCl.	Calculated for $RbCl.SbCl_3$.
Rb	23·67	23·96	24·61
Sb	35·38	34·99	34·53
Cl	40·70	40·73	40·86

A solution of antimony and rubidium chloride in the proportion of $2\frac{1}{2}$ molecules of the former to one of the latter gave a mixture of this salt and the yellow one described below. As has been observed by Remsen and Saunders, crystals of this salt rapidly lose their luster on exposure. They give no definite melting point below the temperature of boiling sulphuric acid.

3:2 Rubidium Antimony Chloride, $3RbCl.2SbCl_3$.—This is the salt to which Remsen and Saunders assign the formula $5RbCl.3SbCl_3$. They obtained this compound on adding "a considerable excess" of antimony chloride to a solution of the salt $23RbCl.10SbCl_3$. They describe the crystals as sometimes resembling a rhombohedron in general shape and having a pale yellow color, and they remark that "this is noteworthy, because the more complex salt ($23RbCl.10SbCl_3$) and the simpler one ($RbCl.SbCl_3$) are both colorless. It is to be remembered, however, that the salt $Cs_3Sb_2Cl_9$ ($3CsCl.2SbCl_3$) is also yellow." It may be added that both $3CsCl.2AsCl_3$ and $3RbCl.2AsCl_3$ are pale yellow. Remsen and Saunders also remark "As the formula of this rubidium salt is not very simple, and as the substance could not be recrystallized, on account of the strong tendency towards the formation of the very complex salt, the formula suggested below can hardly be considered as definitely established."

* Loc. cit.

I have found that when solutions of antimony chloride and rubidium chloride are mixed in the proportion of one and one-fifth molecules of the former to one molecule of the latter a pale yellow-salt is obtained crystallizing in rhombohedrons. In one case on obtaining a crop of crystals from a solution of $2SbCl_3$ to 1RbCl, in strong HCl, the yellow rhombohedrons were seen to be mixed with the colorless hexagonal plates, presumably of the salt $23RbCl . 10SbCl_3$? It was also found that a wide difference exists in the solubility of these two salts in warm solutions, the yellow crystals dissolved with difficulty, while on the other hand, the salt 23 : 10 went into solution with only a slight elevation of temperature. If the crystals of the yellow salt are warmed in the mother liquor they become opaque throughout without losing their pale yellow color. It seems probable that impurities are dissolved out by this operation and that no decomposition takes place, for the decomposition products and the other double chlorides are colorless. An analysis of a crop obtained in this manner corresponded very closely to the formula $3RbCl . 2SbCl_3$. Analysis gave:

	From solutions of $2SbCl_3$ to 1RbCl.		From solutions of $1\frac{1}{2}SbCl_3$ to 1RbCl.		From solutions of $2SbCl_3$ to 1RbCl heated.	Calculated for $3RbCl . 2SbCl_3$.	Calculated for $5RbCl . 3SbCl_3$.
Rb	32·57	32·19	33·34	31·86	31·30	31·44	33·28
Sb	28·68	28·67	28·55	28·46	29·44	29·41	28·03
Cl	38·38	38·42	38·32		38·98	39·15	38·69

23 : 10? Rubidium Antimony Chloride, $23RbCl . 10SbCl_3$. —For the preparation of this compound, a sample of rubidium chloride was used which had been specially purified for the purpose by the method recently described by Professor H. L. Wells* of this laboratory. The purification of this sample was repeated after the product failed to give spectroscopic reactions for potassium and cæsium.

If solutions of antimony and rubidium chlorides are mixed in the proportion of one molecule of $SbCl_3$ to one, four or six molecules of RbCl, the crystals obtained are the "colorless six-sided plates, tables, or thicker crystals," to which Remsen and Saunders have assigned the formula $23RbCl . 10SbCl_3$. The average results of the analyses of the different crops of the double chloride gave figures closely agreeing with those of the above authors, but the ratio of rubidium to antimony came somewhat lower than theirs. Analysis gave:

* This Journal, III, xlvi, 188.

	From solution 6RbCl to 1$SbCl_3$.		From solution 4RbCl to 1$SbCl_3$.	From solution 1RbCl to 1$SbCl_3$.	Sample recrystallized from 10% HCl.	Average.	Ratio.
Rb	38·98	38·55	38·83	38·62	38·60	38·716	2·28
Sb	23·76		23·98	23·52	23·81	23·767	1·00
Cl	37·16	36·97			36·95	37·026	5·26

	Calculated for 23RbCl . 16$SbCl_3$.	Calc. for 16RbCl . 7$SbCl_3$.	Calc. for 9RbCl . 4$SbCl_3$.	Calc. for 7RbCl . 3$SbCl_3$.
Rb	38·96	38·85	38·57	39·21
Sb	23·77	23·86	24·06	23·58
Cl	37·27	37·29	37·37	37·21

It is to be noticed that this salt is formed under conditions varying more widely than in the case of any of the other double rubidium antimony chlorides. It can be exposed to the air for several days without losing its luster; on long exposure it becomes covered with a white, opaque layer, probably of antimony oxychloride.

The Double Bromides.

The bromides were obtained in the form of brilliant yellow, six-sided plates, resembling the double arsenic bromides of rubidium and cæsium. They are comparatively stable in the air, but on long exposure the crystals lose their luster.

3 : 2 Rubidium Antimony Bromide, $3RbBr.2SbBr_3$.—This salt was obtained from dilute hydrobromic acid solutions when the constituents were mixed in the proportion of two and three-tenths and also four molecules of RbBr to one of $SbBr_3$, it was also the only one formed when antimony bromide was present in the solutions in excess. It will be seen that a much larger range of conditions exists for the preparation of the salt $3RbBr.2SbBr_3$ than in the case of the corresponding double chloride. Moreover, the bromide can be recrystallized unaltered from dilute hydrobromic acid.

Analysis gave:

	From solutions containing a large excess of $SbBr_3$.			From solution 23RbBr . to 10$SbBr_3$.	From solution 4RbBr to 1 $SbBr_3$.	Sample of latter recrystallized from HBr.	Calculated for 3RbBr . 2$SbBr_3$.
Rb	21·55	21·18	20·96	21·16	21·53	20·92	21·08
Sb		20·07	20·13	19·98	19·59	19·91	19·73
Br	59·30					59·07	59·19

23 : 10 (?) Rubidium Antimony Bromide, $23RbBr.10SbBr_3$.—This salt was obtained when dilute hydrobromic acid solutions of rubidium and antimony bromides were mixed in the

proportion of six, eight and thirteen molecules of the former to one of the latter. The crystals obtained on slowly cooling these mixtures, with the exception of their strong yellow color, closely resemble the corresponding complex chloride. If the solutions are rapidly cooled the salt separates in the form of brilliant spangles. The average of the following results gives a remarkably close ratio to that required for the formula $23RbBr.10SbBr_3$.

Analysis gave:

	From solution 6RbBr to 1SbBr$_3$.	From solution 8RbBr to 1SbBr$_3$.	From solution 13RbBr to 1SbBr$_3$.			Sample of latter recrystallized from conc. HBr.
Rb	26·66	26·16	26·92	26·60	26·71	26·39
Sb	16·11	16·23	16·18	16·26	16·22	16·18
Br			57·27	57·23		57·41

	Calculated for 23RbBr.10SbBr$_3$.	Calculated for 16RbBr.7SbBr$_3$.	Calculated for 9RbBr.4SbBr$_3$.	Calculated for 7RbBr.3SbBr$_3$.
Rb	26·55	26·47	26·27	26·74
Sb	16·20	16·25	16·38	16·08
Br	57·25	57·28	57·35	57·18

	Average of analytical results.	—— Ratios derived ——					
Rb	26·57	·3107	or	23·03	or	16·12	or	9·21	or	6·90
Sb	16·19	·1349	"	10·00	"	7·00	"	4·00	"	3·00
Br	57·30	·7162	"	53·09	"	37·16	"	21·23	"	15·92

It is to be noticed that this salt is formed within a much smaller range of conditions than in the case of the chloride and can only be recrystallized from strong hydrobromic acid solutions. When recrystallized from moderately strong acid a mixture of the salts 23 : 10 and 3 : 2 was obtained, but from dilute acid a pure crop of the 3 : 2 compound separated.

	Recrystallized from strong HBr.	Recrystallized from dilute HBr.	Calculated for 3RbBr.2SbBr$_3$.
Rb	25·54	21·89	21·08
Sb	16·93	19·70	19·73
Br	57·77		59·19

The Double Iodide.

3 : 2 Rubidium Antimony Iodide, $3RbI.2SbI_3$.—The formation of this salt was observed when a solution of rubidium iodide in hydriodic acid was saturated hot with antimony iodide, it was also obtained from a solution of antimony iodide in a large excess of rubidium iodide. The best crystals are

obtained when a considerable quantity of antimony iodide is present; under these conditions large deep red lozenge shaped crystals separate. Analysis gave:

	Large excess of RbI.	Large excess of SbI_3.	Calculated for $3RbI . 2SbI_3$.
Rb	16·28	14·82	15·64
Sb	14·14	15·17	14·64
I	69·76	69·55	69·72

On exposure to the air the crystals slowly lose their luster.

Crystallography.

The crystallization of the 3 : 2 double salts is hexagonal. In general the habit is rhombohedral and they can all be referred to axes of nearly equal length. The double bromide and iodide have a perfect basal cleavage, like the salts of the arsenic series, while the chloride gave only a conchoidal fracture. The axial ratios of the salts is shown by the following table, the ratios of the corresponding arsenic salts being given for comparison.

	$a : \dot{c}$		$a : c$		$a ; \dot{c}$
$3RbCl . 2SbCl_3$	1 : 1·125	$3RbCl . 2AsCl_3$	1 : 1·210	$3CsCl . 2AsCl_3$	1 : 1·209
$3RbBr . 2SbBr_3$	1 : 1·207	$3RbBr . 2AsBr_3$	1 : 1·220	$3CsBr . 2AsBr_3$	1 : 1·219
$3RbI . 2SbI_3$	1 : 1·230	$3RbI . 2AsI_3$	1 : 1·242	$3CsI . 2AsI_3$	1 : 1·244

From this table it may be seen that the substitution of arsenic by antimony produces little if any effect in the lengths of the axes, and, in each series the vertical axes lengthen as the atomic weight of the halogen increases.

$3RbCl . 2SbCl_3$.—This salt unlike the others of the series, shows rhombohedral tetartohedrism. In one crop, where the crystals measured 5 to 7^{mm} in diameter, the faces were developed on every crystal as in fig. 1, the forms being

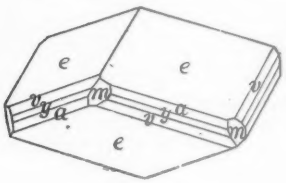


Fig. 1.

a, $11\bar{2}0$, i-2 *e*, $01\bar{1}2$, $-\frac{1}{2}$ *y*, $\bar{2}532$, $-\frac{1}{2}{}^5r$
m, $10\bar{1}0$, I *v*, $\bar{1}3\bar{2}2$, $-\frac{1}{4}$, ${}^3r$

On a second crop only *e* and *a* were developed.

	Measured.	Calculated.
$e \wedge e$, $01\bar{1}2 \wedge 1\bar{1}02$	56° 18′	
$e \wedge v$, $01\bar{1}2 \wedge \bar{1}3\bar{2}2$	29 53	29° 55′
$e \wedge y$, $\bar{1}3\bar{2}2 \wedge \bar{2}5\bar{3}2$	11 29	11 26
$y \wedge a$, $\bar{2}5\bar{3}2 \wedge \bar{1}2\bar{1}0$	20 29	20 29

This salt differs from all the others of the series, since, it is the only one on which tetartohedrism has been observed. Whether the others are really tetartohedral, but have not shown it owing to the absence of highly modified forms, cannot be told at present. Also the basal cleavage, which is so prominent on all of the others, could not be detected, while the one half rhombohedron *e* was only observed on this salt. A basal section was prepared, which in convergent polarized light showed a normal, uniaxial interference figure, the double refraction being negative, like the corresponding arsenic compound.

3RbBr . 2SbBr$_3$. — Crystals of this salt were prepared up to 7^{mm} in diameter. The habit is generally that of six-sided plates, fig. 2, having the forms *c*, 0001, O ; *r*, $10\bar{1}1$, 1 and *z*, $01\bar{1}1$, -1. In one crop *c*, *r* and *m* were developed with some of the rhombohedral faces predominating to such an extent that the crystals looked like prisms, represented in basal projection by fig. 3.

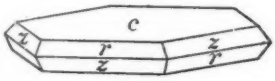


Fig. 2.

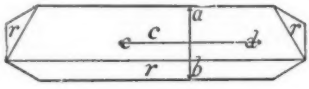


Fig. 3.

	Measured.	Calculated.
$r \wedge c$, $10\bar{1}1 \wedge 0001$	*52° 21′	
$r \wedge z$, $10\bar{1}1 \wedge 01\bar{1}1$	48° 0	47° 57′

None of the crystals show normal optical properties. Crystals like fig. 3 showed for the most part an extinction parallel to the direction *c*–*d*, sometimes with twinned lamellæ prominent at one end. In convergent polarized light no interference figure was observed normal to *c* but some of the crystals like fig. 3 could be tilted up on a rhombohedron face and showed an acute bisectrix nearly normal to *r*. The axial angle was small and the dispersion strong, the optical axes being in the plane *a*–*b* for green and normal to that for red light, the interference figure looking like that of brookite.

3RbI. 2SbI$_3$.—This salt unlike the corresponding arsenic compound was obtained in crystals of considerable size some over 10^{mm} in diameter. When prepared with an excess of SbI_3 usually lozenge-shaped crystals were obtained shown in basal projection in fig. 4. These were often grouped in twin position, penetration twins being prominent with a rhombohedron as twinning plane. From solutions containing an excess of RbI, the rhombohedral habit was observed, sometimes with a negative scalenohedron *s* $18\cdot\bar{9}\cdot17$, $-\frac{7}{17} - \frac{2}{7}$, beveling its pole edges, fig. 5.

	Measured.	Calculated.
$m \wedge r$, $10\bar{1}0 \wedge 10\bar{1}1$	*35° 6′	
$r \wedge c$, $10\bar{1}1 \wedge 0001$	54 43	48° 18′
$r \wedge z$, $10\bar{1}1 \wedge 01\bar{1}1$	47 15	48 18
$r \wedge r$, $10\bar{1}1 \wedge \bar{1}101$	89 50	90 14
$s \wedge s$, $18\bar{9}17 \wedge \bar{1}98\bar{1}7$	6 40	6 21

The basal cleavage was prominent and sections parallel to this showed abnormal optical properties. Thin plates from the crystals like fig. 4 showed middle and end sections with

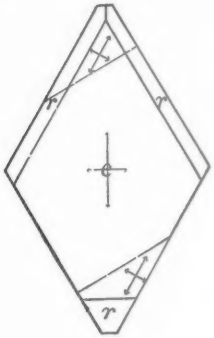


Fig. 4.

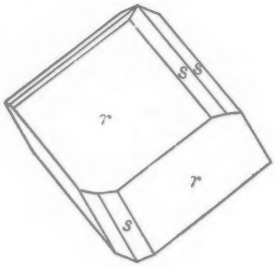


Fig. 5.

extinctions in the directions indicated by the arrows. In convergent light no interference figure was observed. This salt then like $3RbBr.2SbBr_3$ and $3\bar{R}bI.2AsI_3$ is only pseudo-hexagonal being abnormal in its optical properties.

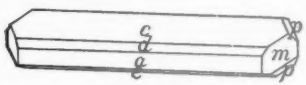


Fig. 6.

$RbCl.SbCl_3$.—The crystallization of this salt is monoclinic. Crystals were obtained 10^{mm} long. The forms observed were

a, 100, *i*-$\bar{i}$	*m*, 110, *I*	*e*, $\bar{1}01$, 1-$\bar{i}$
c, 001, *O*	*d*, 101, —1-$\bar{i}$	*p*, $\bar{1}11$, 1

The habit is shown in fig. 6. The axial ratio is $\dot{a}:\dot{b}:\dot{c} = 1{\cdot}732:1{\cdot}000:1{\cdot}085$; $\beta = 001 \wedge 100 = 65° 34'$.

	Measured.	Calculated.
$a \wedge c$, $100 \wedge 001$	*65° 34′	
$a \wedge m$, $100 \wedge 110$	*57 37	
$c \wedge e$, $001 \wedge \bar{1}01$	*37 36	
$m \wedge m$, $110 \wedge \bar{1}10$	64 46	64° 46′
$a' \wedge e$, $\bar{1}00 \wedge \bar{1}01$	76 54	76 50
$p \wedge e$, $\bar{1}\bar{1}1 \wedge \bar{1}01$	46 28	46 23
$p \wedge c$, $\bar{1}\bar{1}1 \wedge 001$	56 50	56 52
$c \wedge d$, $001 \wedge 101$	24 21	24 22
$d \wedge a$, $101 \wedge 100$	41 24	41 12

In polarized light these crystals show an extinction parallel to the ortho-axis. With crystals flattened parallel to the basal plane an obtuse bisectrix may be seen nearly normal to the base. The plane of the optical axis being at right angles to the symmetry plane.

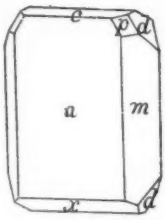


Fig. 7.

RbCl . 2SbCl$_3$. H$_2$O.—The crystallization of this salt is monoclinic. Crystals were made up to a length of about 9 or 10^{mm}. The forms observed were:

a, 100, i-$\bar{i}$		
c, 001, *O*	*d*, 021, 2-$\dot{i}$	*p*, 221, −2
m, 110, *I*	*e*, 011, 1-$\dot{i}$	*x*, $\bar{1}$01, 1-$\bar{i}$

The habit is shown in fig. 7. The axial ratio is $\dot{a} : b : \dot{c}$ 1·699 : 1 : 0·820 $\beta = 001 \wedge 100$ 89° 28½′.

	Measured.	Calculated.
$m \wedge m$, 110 ∧ $\bar{1}$10	*60° 57′	
$a \wedge x$, 100 ∧ $\bar{1}$01	64 49	64° 40′
$m \wedge a$, 110 ∧ 100	59 32	59 32
$a \wedge c$, 100 ∧ 001	*89 28½	
$x \wedge c$, $\bar{1}$01 ∧ 001	*25 51½	
$c \wedge e$, 001 ∧ 011	39 10	39 21
$c \wedge d$, 001 ∧ 021	58 20	58 37
$a \wedge p$, 100 ∧ 221	63 5	63 6
$p \wedge d$, 221 ∧ 021	27 5	26 37

The crystals flattened parallel to the ortho pinacoid, show in polarized light an extinction parallel to the ortho-axis and in convergent light a bisectrix and one of the ring systems appear near the limits of the field. The plane of the optical axis is the clino pinacoid.

The 23 : 10 bromide is pseudo-hexagonal. Basal plates always showed an intricate twinning when examined in polarized light. The pyramidal faces were horizontally striated and to such an extent that no satisfactory measurements could be made. In every respect this compound resembles the 23 : 10 chloride described by Remsen and Saunders.

In conclusion the author wishes to express his indebtedness to Prof. H. L. Wells for valuable advice in connection with the present investigation and to Prof. S. L. Penfield under whose generous supervision the crystallography of these salts was investigated.

Sheffield Scientific School, June, 1893.

Art. XLI.—*On the Separation of Copper from Cadmium by the Iodide Method;* by Philip E Browning.

[Contributions from the Kent Chemical Laboratory of Yale College—XXVIII.]

The separation of copper from cadmium by the precipitation of the cuprous iodide by appropriate means has long been known. Pisani* mentions the fact that potassium iodide can be used to effect precipitations and claims that a satisfactory separation can be made in this way. Flajolot† states that potassium iodide cannot be used as a precipitant on account of the solubility of cuprous iodide in that reagent, nor can hydriodic acid be employed if nitric acid is present. He recommends that the solution containing copper be brought to acidity with sulphuric acid, that a considerable excess of sulphurous acid be added and that the precipitation be effected by hydriodic acid. Under this treatment he finds that only an unweighable or at least a very small trace of copper remains dissolved. Kohner‡ in a paper of more recent date, in which he reviews the various methods for the separation of copper from cadmium, states that the iodide method is impracticable on account of the solubility of cuprous iodide both in excess of hydriodic acid and in potassium iodide.

The work to be described was undertaken to determine if possible under what conditions the method may be safely used. Solutions of copper and cadmium sulphates were made and standardized by treating definite portions, measured from burettes and weighed, by appropriate means, the average of closely agreeing results being taken as the standard. A solution of potassium iodide of approximately ten per cent strength, was used throughout the work. The amount of the copper solution generally taken (25 cm^3) contained about 0·12 grm. of copper and the potassium iodide necessary to completely precipitate the iodide was about 0·6 grm. or 6 cm^3 of the solution. I have in no case used less than 10 cm^3 or 1 grm. of the iodide. In experiments (1) and (2) the free iodine separating on the addition of the potassium iodide was bleached with sulphurous acid and the cuprous iodide filtered off immediately. In experiment (3) no sulphurous acid was added but the solution was boiled until a considerable amount of the free iodine was expelled. In experiment (4) the boiling to expel the free iodine completely was necessarily carried on until the solution was evaporated nearly to dryness. Experiments (5) to (14) were

* Compt. rend.. xlvii. 294.
† Journ. f. prakt. Chem , lxi, 105.
‡ Zeitschr. Anal. Chem., xxvii, p. 203. Jour. Anal. Chem., vol. iii, p. 339.

made to show the effect of varying amounts of potassium iodide, and were all conducted in the same manner, the standard copper solution being measured from a burette into a counterpoised beaker and weighed, the potassium iodide in solution added, the whole evaporated to dryness to insure the expulsion of the iodine, and water added to the amount indicated in the table. The filtration was made under gentle pressure, by means of a Bunsen filtering flask, on an asbestos felt contained in a perforated platinum crucible, the whole having been previously ignited and weighed. It is advisable to use a moderately thick felt and not to allow the felt to run dry nor to remove the pressure during the filtration, on account of the tendency of the cuprous iodide to pull through under these conditions. The precipitate was washed thoroughly with either hot or cold water, the washings never amounting to less than 100 cm^3. The crucible containing the cuprous iodide was placed in an air bath and the precipitate dried at a temperature between 120° C. and 150° C., and weighed. The first weight was uniformly constant. It would seem from experiments (4) to (12) that a moderate excess of potassium iodide has no great solvent effect upon the precipitated cuprous iodide, while free iodine and large amounts of hydriodic acid have a decided solvent effect as shown in experiments (1), (2), (3). In two cases where 1 grm. and 2 grm. respectively of potassium iodide were used to precipitate about 0·12 grm. of copper the filtrate from the first gave no reaction with either ammonia or acetic acid and potassium ferrocyanide, and the second gave no reaction with ammonia and with potassium ferrocyanide only a trace.

These filtrates before testing for copper were treated with potassium nitrite and sulphuric acid to remove the iodide and

SERIES I.*

	Copper taken. grm.	Copper found (weighed as Cu_2I_2). grm.	Error in Copper. grm.	KI used. grm.	Final volume of liquid. cm^3.
(1)	0·1189	0·1093	0·0096—	1	300
(2)	0·1197	0·1050	0·0147—	"	"
(3)	0·1191	0·1056	0·0135—	"	"
(4)	0·1194	0·1189	0·0005—	"	"
(5)	0·1194	0·1196	0·0002+	"	100
(6)	0·1191	0·1194	0·0003+	"	"
(7)	0·1193	0·1193	0·0000	2	"
(8)	0·0049	0·0045	0·0004—	"	"
(9)	0·0051	0·0047	0·0004—	"	"
(10)	0·1195	0·1195	0·0000	3	"
(11)	0·1192	0·1188	0·0004—	4	"
(12)	0·1191	0·1189	0·0002—	"	200
(13)	0·1193	0·1182	0·0011	5	"
(14)	0·1193	0·1179	0·0014—	"	"

* The copper is calculated as the metal in this table.

oxidize the copper. I have no doubt that when the potassium iodide is in excess some copper goes into solution, but the amount is very small unless the excess of iodide is very great. I may add here that when the potassium iodide is in very large excess the mixture of potassium iodide and cuprous iodide melts as the solution becomes concentrated by evaporation and a solution is obtained having a deep iodine color. This color does not disappear on further evaporation and the result obtained upon filtering the cuprous iodide after dilution with water invariably shows considerable loss. In the event of noticing the phenomenon mentioned it is best to throw aside the determination before completion and start another using less of the iodide.

The separation of the copper from the cadmium was taken up next. Definite portions of the cadmium solution were measured into the same beakers with the copper solution and weighed, and enough potassium iodide was added to precipitate the whole as cuprous iodide if no cadmium were present. The solution was evaporated to dryness to remove iodine and diluted to the amount stated in the table. The precipitated cuprous iodide was filtered upon an asbestos felt, thoroughly washed, dried and weighed as before described. The filtrate and washings contained, of course, the cadmium together with the excess of potassium iodide and potassium sulphate formed in the reaction, and the determination of the cadmium was not as simple a matter as might at first be supposed. In the presence of potassium iodide, hydrogen sulphide did not give a precipitate in acid or neutral solution which could be filtered. After removing the potassium iodide, however, by treating with sulphuric acid and potassium nitrite, it was found to be possible to precipitate all the cadmium as sulphide, but in such form that filtration was extremely slow, which was peculiarly disadvantageous in this case inasmuch as the presence of the large amount of alkaline salts present made prolonged washing of the sulphide necessary. Ammonium sulphide gave better results, the precipitate falling in good form even in the presence of potassium iodide, but here also the slow filtration was a disadvantage. I have had recourse therefore to the method of precipitating by sodium carbonate and weighing as oxide. This method has generally been regarded as inaccurate, but my experience has shown that it is one of the best of the processes employed for the estimation of cadmium when the filtrations and ignitions are made upon asbestos. Two determinations of the cadmium alone gave results agreeing closely with the standard determinations made by evaporating definite portions of the solution of the sulphate to dryness and igniting at low redness and weighing as the anhydrous sulphate.

The filtrate containing the cadmium was heated to boiling and sufficient sodium carbonate added to complete the precipitation. On further boiling the precipitate became granular and filtered easily. The precipitate was washed with hot water several times by decantation, the washings being passed through the felt to prevent loss of any of the precipitate. Washing was continued until the filtrate gave no reactions for either sulphate or iodide. The crucible containing the carbonate was heated gently at first, then gradually to a higher degree until the lower half of the crucible was red and the white carbonate had changed to the brown oxide. This heating was repeated until a constant weight was obtained. In some of the separations the faintest suspicion of a blue color in the carbonate suggested the presence of the fraction of a milligram of copper which probably escaped the separation process.

SERIES II.

	Copper taken.	Copper found (weighed as Cu_2I_2).	Error on Copper.	Cadmium taken.	Cadmium found (weighed as CdO.)	Error on cadmium.	KI used.	Found volume of liquid.
	grm.	grm.	grm.	grm.	grm.	grm.	grm.	cm^3.
(1)	0·2383	0·2386	0·0003+	0·0484	0·0490	0·0006+	2	100
(2)	0·1192	0·1185	0·0007−	0·2439	0·2430	0·0001+	"	"
(3)	0·1193	0·1194	0·0001+	0·1942	0·1942	0·0000	"	"
(4)	0·1188	0·1190	0·0002+	0·2422	0·2421	0·0001−	"	200
(5)	0·1201	0·1201	0·0000	0·2426	0·2428	0·0002+	"	100
(6)	0·1193	0·1193	0·0000	0·2436	0·2433	0·0003−	"	"
(7)	0·0239	0·0238	0·0001−	0·1934	0·1932	0·0002−	1	"
(8)	0·0236	0·0239	0·0003+	0·1942	0·1936	0·0006−	"	"
(9)	0·0239	0·0242	0·0003+	0·1444	0·1442	0·0002−	"	"
(10)	0·0238	0·0238	0·0000	0·1467	0·1461	0·0006−	"	"

The method is simple in manipulation and the results are fairly accurate.

ART. XLII.—*A New Meteorite from Hamblen County, Tennessee;* by L. G. EAKINS.

THIS meteorite, which was found in September, 1887, on a ridge about six miles W.S.W. from Morristown, Hamblen County, Tennessee, was first recognized and brought to notice by Professor J. M. Safford, of Nashville, who, in course of an inspection of a collection of iron ores, recognized some fragments as undoubtedly meteoric.

Professor Safford at once took steps to secure these pieces, and visited the locality where they were found. Here he succeeded in finding a few more fragments, which had the appearance of having been buried in the soil and afterward turned

up by the plow. These various pieces now in Professor Safford's possession have a total weight of about 36 pounds, two of them weighing respectively 11 pounds and 13 pounds. A specimen sent by Professor Safford to the U. S. National Museum, and now in its collection, furnished the material for this investigation.

Most of the pieces show much surface oxidation; a fresh fracture showing a gray color, with numerous metallic particles of nickel iron.

The analysis was made in the usual way for this class of meteorites; that is, by separating the metallic and siliceous portions, both by picking and by the magnet, and analyzing separately the nickeliferous iron, the silicates soluble in hydrochloric acid and those insoluble. The metallic and siliceous portions of this meteorite are, approximately, equal in amount; the iron being quite malleable and unusually tough.

The analysis is as follows:

Nickeliferous Iron.

Fe	90·92
Ni	7·71
Co	·80
Cu	tr.
P	·19
S	·04
	99·66

Siliceous Portion.

	Soluble in HCl.			Insoluble in HCl.		
	Analysis.	Calc. to 100%	Molecular ratios.	Analysis.	Calc. to 100%	Molecular ratios.
SiO	16·79	45·61	·760	31·47	50·67	·844
Al_2O_3	8·33	22·62	·222	9·25	14·89	·146
Cr_2O_3	----	----	----	·82	1·32	·009
FeO	4·88	11·73	·163	6·55	10·55	·147
NiO	·39	1·06	·014	----	----	----
MnO	----	----	----	·47	·76	·010
CaO	5·19	14·09	·252	2·24	3·61	·064
MgO	1·34	3·64	·091	11·16	17·98	·449
K_2O	----	----	----	·02	·03	·003
Na_2O	----	----	----	·12	·19	·003
P_2O_5	·46	1·25	·009	----	----	----
S	·25	----	----	----	----	----
	37·63	100·00		62·10	100·00	

In calculating the analysis of the soluble portion to 100 per cent, the S and an amount of iron (·56 per cent FeO) sufficient to form FeS, are first deducted.

In many stony meteorites olivine is a considerable constituent, generally forming the bulk of the soluble silicate; but in this case the analysis shows olivine to be present in but small proportion, if at all. It is interesting to note that both the soluble and insoluble portions have practically the same molecular ratios, the soluble portion reducing itself essentially to RAl_2SiO_6, in which R=Ca, Fe; and the insoluble part to the same formula, where R=Mg, Fe; both being equivalent to aluminous enstatite or pyroxene.

At the time this analysis was made it was impracticable to supplement the work with the proper microscopical examination of sections, which, doubtless, in conjunction with the chemical evidence would have satisfactorily determined the minerals present. Without this microscopical knowledge, however, little that is definite can be said, except that there seem to be present two similar molecules; the one in which lime predominates being soluble, and the other, magnesian, being insoluble in hydrochloric acid.

The other alternative is to assume a complex molecule which is split into two sections by the action of the acid.

The meteorite is now known as the Safford meteorite.

Laboratory U. S. Geological Survey.

ART. XLIII.—*On the Ventral Plates of the Carapace of the genus Holonema of Newberry;* by HENRY S. WILLIAMS.

IN the summer of 1890 I exhibited photographs of several plates, associated together on a slab of sandstone which I referred to *Holonema*, one of the plates (*m. v.* of figure beyond) being the same in shape and markings as the original plate described by Claypole as the "ventro-median" or "lozenge-plate" of "Pterichthys," and named by him *Pterichthys rugosa.** Messrs. Cope and Claypole both examined my photograph at the time and remarked upon the close resemblance to the arrangement of plates on the back of *Bothriolepis.* In the account given by Claypole in the American geologist,† the plates are described as dorsal, and their position is reversed, the plate *a. m. v.*, or anterior median ventral, being called "post-dorso-median," although the general shape of the plates is correct, it having been reproduced, mainly, from a copy of my photograph.‡

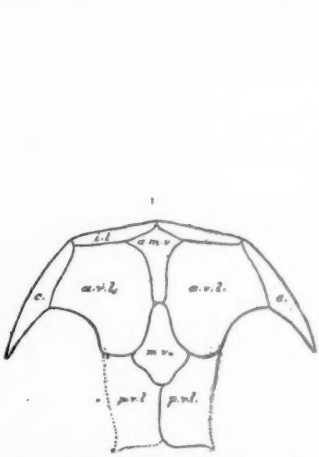
In the Proceedings of the U. S. National Museum, vol. xiv, p. 256, Cope refers to the same photographs as representing

* Am. Phil. Soc., 1883.

† Vol. vi, p. 255, 1890.

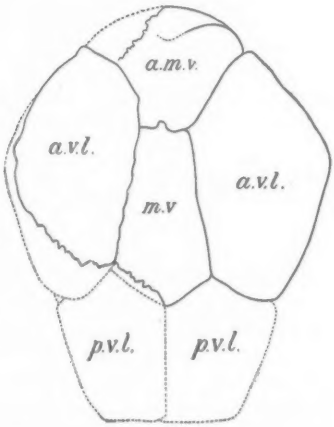
‡ See figure, ibid., page 256.

the posterior part of the carapace, speaking of the plates *a. v. l.* (fig. 2, beyond) as "posterior lateral" dorsals. My first impression was that the plates were ventral; and in a letter from Dr. Newberry the same interpretation of the plates was made. "I imagine your plates are from the plastron," . . . "there should be two other plates in the plastron overlapping the posterior end" of the plate marked *m. v.*, which he spoke of as the "central plate of the plastron;" and he further said, "your plate A (*a. m. v.* of fig. 2) is altogether new." With this conflict of opinion and knowing then of no analogous arrangement of plates by which to settle the question, I left the matter for further light. The restoration of the ventral plates of the carapace of *Phlyctænaspis acadica* Whiteaves, by Traquair,* furnishes the needed clue. Whiteaves had described the dorsal part of the carapace as *Coccosteus acadicus*, and had figured two plates which he referred to the ventral part of the same. His specimens were from the lower Devonian of Cambelltown in Canada.† Dr. Traquair on examining specimens from the same locality discovered a large portion of the ventral shield, with nearly all its plates *in situ*, and



Restoration of ventral plates of *Phlyctenaspis Acadica* Whiteaves, after Traquair. Reduction about $\frac{1}{4}$.

2.



Restoration of ventral plates of *Holonema rugosa* Claypole. Reduced to $\frac{1}{3}$ nat. size.

from it, with the aid of detatched specimens, the restoration was made, of which a copy is given in figure 1. Examination of the restoration and its description shows the probable rela-

* Geol. Mag., 1893, p. 148.

† Trans. Roy. Soc. Canada, vol. vi, sect. iv, p. 3. pl. IX, with a woodcut.

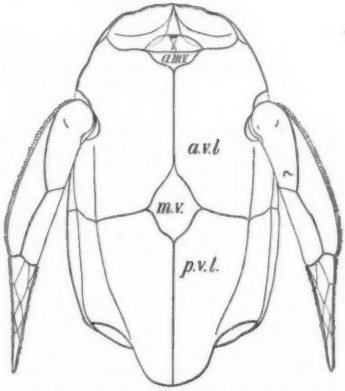
tions of the plates of *Holonema*, as will be seen by comparing figures 1 and 2.*

The corresponding plates are indicated by the same letters in the two figures: *i. l.*, interlateral, *c.*, cornu or lateral spine, *a. m. v.*, anterior median ventral, *a. v. l.*, anterior ventro-lateral, *m. v.*, median ventral, *p. v. l.*, posterior ventro lateral. The continuous lines indicate outlines that are preserved in the specimens, and the dotted lines, the probable outlines of the perfect plate.

On the specimen from which figure 2 is made there are also traces of impressions of heavy spine-like bones, but their shape is not determined; their presence however is sufficient to indicate that the same animal, of which the plates figured are preserved, possessed also either pectoral limbs or, at least, some more massive bones than the thin, flat plates of which the form is distinctly preserved.

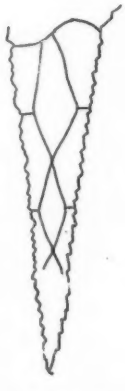
The "pectoral limb," or "pectoral spine" as it is called in the description by Cope† (fig. 5), is probably the terminal

3.



Ventral carapace of *Pterichthys* (*Bothriolepis*) *canadensis* Whiteaves, after Whiteaves. ½.

4.



Terminal finger of pectoral limb of *B. canadensis*, nat. size, after Whiteaves.

5.

"Pectoral spine of *Holonema* sp." nat. size, after Cope.

* After handing this paper to the editor I have noticed that Mr. A. Smith Woodward had already pointed out Claypole's error of interpretation, saying "The post-dorso-median" plate of Claypole is obviously the anterior median ventral, while the "post-dorso-lateral" and "dorso-lateral" of the same author are the anterior and "posterior ventro-lateral plates respectively." Catalogue of Fossil Fishes, Brit. Museum, part II, p. 315.

† On the pectoral limb of the genus Holonema of Newberry; Proc. U. S. N. Museum, vol. xiv.

part of the pectoral limb of *Bothriolepis canadensis*. The "three elongate narrow hexagons," with "sutures extending from the lateral angles of the hexagons to the border of the spine" described by Cope as characteristic of this spine of *Holonema*, correspond so exactly to the sutures of the terminal finger of the limb of *Bothriolepis canadensis* figured by Whiteaves (figures 3 and 4) as to suggest not only generic but specific identity. From the figure given by Cope, with the interpretation of its relations here given, it may be inferred that there was some motion at the joint between the two parts of the arm. Pander's dissection and description of the arm of *Asterolepis* make the movement to have probably been of no great amount.

It is hoped that other bones or plates may be brought to light illustrating the structure of this interesting genus of fishes. The specimen from which the above restoration was made was found by Prof. C. S. Prosser, near Oxford, N. Y. in the Oneonta sandstone, of the lower part of the Upper Devonian.

ART. XLIV.—*On some Minerals from the Manganese Mines of St. Marcel, in Piedmont, Italy;* by S. L. PENFIELD.

Alurgite.

IN 1865 Breithaupt gave a brief description* of a deep red mica from St. Marcel, to which he gave the name *alurgite*, from *ἀλουργός*, meaning *purple*. The portion which he at that time had selected for analysis was accidentally lost and since then it seems never to have been investigated. The writer's attention was called to the mineral by Dr. A. E. Foote of Philadelphia, who sent some of it to New Haven for identification, and a preliminary examination, followed by a chemical analysis and a study of its physical properties have shown that it is a distinct species. Its identity with the alurgite of Breithaupt, was first suggested to the writer by Prof. A. J. Moses of the Columbia School of Mines and has been confirmed by Prof. A. Weisbach of the Bergakademie at Freiberg, to whom specimens were sent and to whom the author's thanks are due for comparing them with Breithaupt's original specimens.

The crystallization of alurgite is monoclinic; the structure is micaceous and the cleavage basal, though not so perfect as

* Berg- und hüttenmännische Zeitung, xxiv, p. 336, 1865.

that of muscovite. Cleavage plates are flexible and somewhat elastic. No distinct crystals have been observed but Breithaupt mentions plates with traces of hexagonal outline. The mica occurs as an aggregate of plates, imbedded in a soda rich pyroxene, which will be described later on. The largest cleavage plates that have been observed are about 15^{mm} in diameter. When examined in convergent polarized light some show a uniaxial others a biaxial interference figure, the double refraction being rather strong and negative. Breithaupt mentions a uniaxial interference figure, but in a footnote states that at the same locality a second mica is found, somewhat lighter in color, which is strongly biaxial. The uniaxial character is undoubtedly the result of twinning, for plates can be found, which in some parts are uniaxial, in others biaxial, and where the plane of the optical axes is in two different positions. Some, moreover, give a confused interference figure, as would be expected from two or more biaxial plates, placed one above the other in twin position. There is no difference in specific gravity between the uniaxial and biaxial plates, they are identical in behavior before the blowpipe and there is every reason for believing that they are the same chemical substance. Two measurements were made of the divergence of the optical axes as follows:

$$2E.y.\,(\text{Na flame}) = 57^\circ\ 0'\ \text{and}\ 56^\circ\ 5'$$

The dispersion is distinct, $\rho > v$.

When treated with a mixture of strong hydrofluoric and sulphuric acids the biaxial plates show monosymmetric etching figures while those of the uniaxial plates are triangular or hexagonal, similar to those of muscovite and biotite, described by H. Baumhauer.* The percussion figure is a normal six rayed star. The mica is of the first class according to Tschermak, the plane of the optical axes being at right angles to the symmetry plane, as shown by the etching or the percussion figure. The color will serve as one of the best means of identifying this mica. It is a deep brownish-copper red; the intensity of which in transmitted light, varying of course with the thickness. Cleavage pieces have something the color of clear chips of almandine garnet. The basal cleavage gives a peculiar pearly luster and a sort of coppery metallic tone, like some varieties of red foil. Breithaupt compares the color to lamellar cinnabar and its resemblance to some of the foliated zincite from Franklin, N. J., is very close. The fine powder is pale pink. What is rather remarkable for a colored mica is that its ratio of absorption is so nearly alike in all directions

* Sitzb. Akad. München, 1874, p. 245 and 1875, p. 99.

that its pleochroism is not very marked; the axial colors for a and c are red with a purplish cast, for b brownish red.

Before the blowpipe alurgite first swells and then fuses at about 3 to a slightly yellowish, blebby glass and gives a faint potash flame. With sodium carbonate in the oxidizing flame a green bead, Mn, but with borax a violet color is only obtained after adding a large quantity of the mineral, indicating that the amount of manganese is not very great. In the closed tube at high temperature neutral water is given off. The finely powdered mineral is almost absolutely insoluble in boiling concentrated sulphuric or hydrochloric acids. After fusion it is also insoluble. The specific gravity of a number of pieces was taken by means of the heavy solution, and found to be between 2·835 and 2·849. Breithaupt gives 2·984–3·00. The hardness is about 3.

The results of the analysis of the air dry powder are given below under A. Under B we have the same after calculating Fe_2O_3 and Mn_2O_3 as Al_2O_3, MnO as MgO, Na_2O as K_2O and recalculating to 100 per cent.

	A.	B.	Ratio.			
SiO_2	53·22	53·57	·893	SiO_2	·893	
Al_2O_3	21·19	22·68	·222	$(AlOH)O$	·444	
Fe_2O_3	1·22					
Mn_2O_3	·87					
MnO	·18					
MgO	6·02	6·16	·154	$(MgOH)_2O$	·077	
K_2O	11·20	11·80	·125	K_2O	·125	.224
Na_2O	·34					
H_2O	5·75	5·79 ÷ 9	·643	H_2O	·022	
	99·99	100·00				

The water was determined as loss on ignition, and that it is present in the mineral as hydroxyl is shown by the following fractional determinations:

Two hours at 100° C.	0·74
" " " 200 "	0·48
" " " 300 "	0·17
Total	1·39 per cent loss.

The iron was found to be all ferric and, moreover, when weighed quantities of the mineral and ferrous sulphate were dissolved together in sulphuric and hydrofluoric acids, and titrated with potassium permanganate, it was found that some of the ferrous sulphate was oxidized by the mineral, which must have resulted from the presence of a higher oxide of

manganese. The amount of this oxidation was determined and gave a basis for calculating the per cent of Mn_2O_3, a blank determination having previously given the trifling amount of oxidation from the air, which was deducted in the calculation. It is probable that the deep red color of the mineral is due to the presence of Mn_2O_3, for it is well known that the higher oxides of manganese have intense coloring power, while that of MnO is very slight. Thus this mineral with about one per cent of the oxides of manganese has a much deeper color than rhodonite with 50 per cent of MnO.

In calculating the formula it was found that the amount of hydroxyl was a little more than sufficient to unite with the alumina to form the bivalent radical (AlOH) and with the magnesia to form the univalent radical (MgOH). Regarding the $(MgOH)_2O$ and the slight excess of H_2O as isomorphous with K_2O the ratio of the $SiO_2 : (AlOH)O : [(MgOH), K, H]_2O = \cdot893 : \cdot444 : \cdot224 = 4\cdot0 : 1\cdot99 : 1\cdot00$ or $4 : 2 : 1$. The formula is then $R_3(AlOH)_2Si_4O_{11}$ where R equals MgOH, K and very little H, but it seems still better to write this as a metasilicate, $HR_2(AlOH)AlSi_4O_{12}$. According to the mica theory of Prof. F. W. Clarke* this composition can also be expressed as a combination of the following molecules in the proportion 1 : 1

$$\begin{matrix} & \diagup Si_2O_6 \equiv H_2 \\ Al- & Si_2O_6 \equiv R_2 \\ & \diagdown Si_2O_6 \equiv Al \end{matrix} \qquad \begin{matrix} & \diagup SiO_4 \equiv R_2 \\ Al- & SiO_4 \equiv \left(AlOH\right)_2 \\ & \diagdown SiO_4 \equiv \end{matrix}$$

Chemically this mica is distinct from any known species. It is more closely related to lepidolite than to any of the others, being similar to it in the SiO_2. Al_2O_3 and K_2O percentages. The composition of both can be expressed as metasilicates, they are insoluble in acids and before the blowpipe are easily fusible. Although essentially a potash alumina mica, it differs from muscovite in its high SiO_2 and low Al_2O_3 and in its fusibility, while it is still further removed from biotite and manganophyllite, with which it has been correlated by some authors, by its high silica and insolubility in acids. In a classification, therefore, alurgite should occupy a position near lepidolite and as a distinct species.

Pyroxene rich in soda, or jadeite.

The alurgite is associated with and imbedded in a soda rich pyroxene. This occurs as an interwoven aggregate of prismatic crystals, resembling in structure a rather coarsely crystallized jadeite. The material is very tough and shows no

* This Journal, III, xxxviii, p. 384.

crystal faces. The color is a sort of ash gray with a slight reddish tone. Specimens of the gray tephroite associated with the foliated red zincite from Franklin, N. J., bear a most remarkable resemblance to those of this pyroxene with the alurgite. Before the blowpipe it fuses readily to a black bead and imparts a yellow color to the flame. With the fluxes it reacts for iron and manganese. It is insoluble in hydrochloric acid. In thin sections under the microscope the presence of a black ore, piedmontite, alurgite and numerous minute rutile crystals could be detected. The pyroxene showed a prismatic development, a large angle of extinction and a faint though perceptible pleochroism; in clinopinacoid sections for a very pale rose, for c very pale blue. A section across the prism showed the characteristic prismatic cleavage of pyroxene, and in convergent light an optical axis, nearly in the center of the field, the plane of the optical axes being the clinopinacoid. Sections which approximated closely to the orthopinacoid also showed in convergent light an optical axis; all indicating the pyroxene character.

The material for the chemical analysis was crushed and sifted to a uniform grain and separated by means of the barium mercuric iodide solution. The material was not quite uniform in specific gravity, and, therefore, fearing that it might be a mixture, two portions were taken. The one for analysis A varying between 3·382 and 3·338 and for analysis B between 3·338 and 3·257. These portions when examined with the microscope were found to be quite free from impurities, the heavier showing occasional particles of piedmontite and on the whole somewhat clearer grains than those of portion B. The analyses of the two portions are as follows:

	A.	B.	Mean.	Ratio.		$CaMg(SiO_3)_2$.	$NaR(SiO_3)_2$.
SiO_2	54·39	54·78	54·59	·910		·264	·646
Al_2O_3	9·93	9·56	9·74	·095			
Fe_2O_3	11·78	12·19	11·99	·075	·177		·177
Mn_2O_3	1·21	·92	1·06	·007			
MnO	·66	·50	·58	·008			
MgO	5·01	5·06	5·03	·126	·264	·264	
CaO	7·29	7·19	7·24	·130			
Na_2O	9·40	9·24	9·32	·150	·153		·153
K_2O	·24	·24	·24	·003			
Ign	·38	·35	·37				
	100·29	100·03	100·16				

The two analyses are so nearly alike that they will serve as duplicates, showing that the material was quite pure and homogeneous. In calculating a formula, therefore, the ratio has

been derived from the average. It will be seen from the ratio that the MgO and CaO are present in the proportion 1 : 1 as in normal diopside $MgCa(SiO_3)_2$. Deducting from the total ratio $MnO+MgO+CaO : SiO_2 = \cdot264 : 264 = 1 : 1$, there remains $SiO_2 : Al_2O_3 + Fe_2O_3 + Mn_2O_3 : Na_2O + K_2O = \cdot646 : \cdot177 : \cdot153 = 4\cdot00 : 1\cdot09 : 0\cdot94$ or nearly 4 : 1 : 1, which is required by a metasilicate of the general formula $NaR(SiO_3)_2$. The mineral may therefore be considered as containing the following molecular compounds :

Diopside	$MgCa(SiO_3)_2$	28·8 per cent.
Jadeite	$NaAl(SiO_3)_2$	35·7 "
Acmite	$NaFe(SiO_3)_2$	32·5 "
?	$NaMn(SiO_3)_2$	3·0 "
		100·0 "

These results throw some light on the soda and sesquioxide rich pyroxenes, showing that in this case, at least, they are normal metasilicates. Moreover this mineral holds about the same relation to the pyroxenes that glaucophane does to the amphiboles, being also similar in the orientation of its pleochroism.

As far as can be learned, the pyroxene which agrees most closely with this in composition is a jadeite or chloromelanite from Mexico, analyzed by A. Damour* and containing 8·89 per cent of Fe_2O_3, equivalent to 25·7 per cent of the acmite molecule. The color is described as black, in thin section deep green and this is in strong contrast to the Piedmont mineral, which with a larger percentage of Fe_2O_3 is light in color. It is a well known fact that glasses which are colored green by iron can be decolorized by a higher oxide of manganese, and probably in this case the presence of about 1 per cent of Mn_2O_3 has served to complement the green color which would be expected from the large percentage of the acmite molecule.

Violan.

In 1833 Breithaupt† described a mineral of rare occurrence at Piedmont, to which, from its beautiful blue color, he gave the above name. No chemical analysis was given but only a description of its physical and pyrognostic characters.

Des Cloizeaux‡ has given a brief description of the crystals, on which he was able to identify in the prismatic zone the forms 100, 010, 110 and 120, as well as a prismatic cleavage,

* Bull. Soc. Min. de France, iv, 1881, p. 157. Also Dana's System of Min., Sixth edition, analysis 26, page 370.

† Jour. prak. Chem., xv, p. 329. ‡ Manuel de Minéralogie, 1862, p. 66.

all corresponding closely in their angles to pyroxene. He also presents an analysis by Damour which, as the material was impure from the presence of a fibrous mineral supposed to be tremolite, he regards as only approximate. Later* he showed that the optical properties were like those of diopside and presented an additional analysis by Pisani. A chemical analysis has also been made by Schluttig.† The analyses, all of which are given on page 357 of the sixth edition of Dana's System of Mineralogy, show considerable variation and do not yield a satisfactory formula.

In studying out the relations of the light colored pyroxene associated with alurgite, to the other members of the pyroxene family, it seemed to show a similarity to violan, especially as the analyses showed that they were both rich in soda and contained manganese and sesquioxides. As there was an excellent specimen of violan in the collection of Prof. Brush it seemed best to make a new analysis of it. The material was selected by hand and after crushing and sifting to a uniform grain it was separated by means of barium mercuric iodide solution. The portion that was taken for analysis varied in specific gravity between the limits 3·272 and 3·237. As given by other authors it varies from 3·21 to 3·233. The material when examined under the microscope was apparently very pure. The color was a beautiful light blue. The analysis is as follows:

		Ratio.		$NaR(SiO_3)_2$.	$CaMg(SiO_3)_2$.
SiO_2	53·94	·899		·084	·815
Al_2O_3	1·00	·010			
Fe_2O_3	·86	·005	·021	·021	
Mn_2O_3	·88	·006			
MnO	·36	·005			
MgO	16·63	·416	·846		·846
CaO	23·80	·425			
Na_2O	1·22	·020	·021	·021	
K_2O	·05	·001			
Ign.	·66				
	99·40				

These results differ from those of other investigators in showing less alkalies and sesquioxides. Moreover the identity which Igelström‡ has sought to establish between violan and the mineral from Jakobsberg, Wermland, described by him§

* Manual de Minéralogie, vol. ii, 1874, p. xix.
† Inaug. Diss. Leipzig, 1884. Zeitschr. Kryst., vol. xiii, p. 74.
‡ Jahrb. f. Min., 1890, 2, p. 270. § Jahrb. f. Min., 1889, 2, p. 36.

under the name anthochroite is not confirmed by this analysis inasmuch as there is a marked difference in the ratio of the alkalies to the sesquioxides. As may be seen from the ratio in the author's analysis the alkalies and sesquioxides are present in the proportion 1:1, suggesting a molecule of the jadeite type, while MgO and CaO are also present as 1:1 as in normal diopside. Taking from the total ratio $Na_2O : R_2O_3 : SiO_2 = \cdot021 : \cdot021 : \cdot084 = 1:1:4$, there remains $MnO + MgO + CaO : SiO_2 = \cdot846 : 815 = 1\cdot04 : 1$ or nearly 1:1 as required by diopside. The composition of violan may therefore be expressed as a mixture of the following metasilicates.

Diopside	$MgCa(SiO_3)_2$	90·8 per cent.
Jadeite	$NaAl(SiO_3)_2$	4·1 "
Acmite	$NaFe(SiO_3)_2$	2·4 "
?	$NaMn(SiO_3)_2$	2·7 "

The mineral is therefore essentially a blue variety of diopside, containing small quantities of various well recognized pyroxene molecules.

An azure blue pyroxene has recently been described by Merrill and Packard* from the Middle Gila, New Mexico. Their analysis corresponds essentially tc a normal diopside, with only 1·11 per cent of FeO and the blue color is regarded by them as due to the ferrous iron.

Laboratory of Mineralogy and Petrography,
Sheffield Scientific School, June, 1893.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Absorption-spectra of Copper salts.* — The absorption-spectra of aqueous solutions of copper chloride, sulphate and nitrate have been examined by Ewan, using Krüss's universal spectrometer for the purpose and employing Vierordt's method. The conclusions reached in the investigation may be summed up as follows: (1) On diluting their solutions the absorption-spectra of all the three salts examined are observed to change; (2) the character of these changes is such as to show that the spectra, in dilute solutions tend to become identical; (3) the behavior of the salts examined leads to the conclusion that in strong solutions, the acid and basic parts of the salts are associated in producing absorption of light whilst in dilute solutions they act independently in doing so; (4) these results are substantially in agreement with the hypothesis of electrolytic dissociation; (5) and finally the results obtained do not seem to

* This Journal, III, xliii, 1892, p. 279.

be satisfactorily explicable upon the hypothesis of a hydrolytic dissociation or on that of molecular aggregates.—*Phil. Mag.*, V, xxxiii, 317; *J. Chem. Soc.*, lxiv, II, 149, April, 1893. G. F. B.

2. *On the Separation of Gases from each other under the influence of the Electric discharge.*—It has been observed by BALY, that on passing the electric discharge through a vacuum-tube containing only a small quantity of hydrogen the hydrogen lines are observed only in the spectrum of the negative glow and not at all in the body of the tube. This as he shows is due to an accumulation of the hydrogen about the negative electrode; and by employing tubes of suitable shape containing mixtures of carbon dioxide and hydrogen at about $0{\cdot}75^{mm}$ pressure, he has succeeded in effecting so complete a separation of the hydrogen that, on sealing off the portion of the tube containing the positive electrode, only a trace of hydrogen can be detected in it by spectroscopic tests. Mixtures of hydrogen with other gases, such as nitrogen, carbon monoxide, sulphur dioxide, iodine, and mercury vapor behave similarly. When a mixture of carbon monoxide and carbon dioxide is used, the former gas separates at the negative electrode. When nitrogen is mixed with the carbon dioxide, the separation of the two is very complete. Moreover sulphur dioxide and carbon dioxide may be thus separated. Air must be highly rarefied before separation begins and then the oxygen appears to go to the negative electrode. No relation could be observed between the molecular masses of the constituent gases and the separation of the mixtures. The author points out an apparent connection between this kind of separation and striated discharges; the striæ being strongly marked only when separation occurs and never appearing if the contents of the tube remains homogeneous. If the negative electrode be made a mere point so as to prevent the formation of a glow around it, no striation nor separation is observed. Moreover pure gases do not stratify, iodine, sulphur, arsenic and mercuric iodide giving only a phosphorescence throughout the tube. Prepared in a state of considerable purity, hydrogen itself showed but traces of striation; and from this the author concludes that pure hydrogen would not stratify at all, stratification being a phenomenon due to the separation of two gases.—*Phil. Mag.*, V, xxxv, 200; *J. Chem. Soc.*, lxiii, II, 253, June, 1893. G. F. B.

3. *On the Determination of Molecular Mass from the Rate of Evaporation.*—It is well known that when a non-volatile substance is dissolved in a fairly volatile liquid, the rate of evaporation of this liquid is decreased. This result may probably be attributed to the fact that in the case of the solution, the surface exposed is composed partly of the molecules of the volatile solvent and partly of the molecules of the non-volatile dissolved substance; while when the solvent alone is exposed to evaporation its surface consists wholly of volatile molecules. Evidently therefore the greater the number of non-volatile molecules the less the evaporation. In other words, the rate of evaporation of

such a solution will decrease regularly with its concentration and will be inversely proportional to the molecular mass of the dissolved substance. Hence the molecular mass of any substance may be determined from the rate of evaporation of one of its solutions, as it may from the depression of the freezing point. KRONBERG has experimented to determine the best conditions required to put this method into operation. To make a determination, weighed quantities of two solutions, one of a substance of known, the other of a substance of unknown molecular mass, in the same solvent, should be exposed, either in the open air or in a vacuum for a given time and then reweighed. The losses in each case, calculated for one hundred parts of the pure solvent, will be inversely proportional to the molecular masses of the dissolved substances; and since one of them is known the other is readily calculated.—*Monatsb. Chem.*, xiv, 24; *J. Chem. Soc.*, lxiii, 261, June, 1893. G. F. B.

4. *On the Boiling and the Freezing points of Nitrogen monoxide.*—RAMSAY and SHIELDS have determined with care the temperature at which liquid nitrogen monoxide boils and the temperature at which it solidifies at ordinary atmospheric pressure. For this purpose they employed a hydrogen thermometer, readings of the pressure being taken at constant volume. The error arising from the difference of temperature between the stem and the bulb and that due to the alteration in the volume of the bulb were eliminated by the method used. The plan adopted was to read the position of the mercury in the capillary stem when the bulb was immersed in water at atmospheric temperature; to raise it to about 100° by covering it with cotton-wool and exposing it to the steam of boiling water and to read the increase of the pressure of the gas; and then to immerse it in the boiling nitrogen monoxide and again to read the pressure, which then of course is reduced. Three determinations of the boiling point made in this way gave the values −90·1°, −89·8° and −89·5°; the mean being −89·8°. The liquid should be kept actively boiling during the pressure reading, in order to prevent superheating. The solid nitrogen monoxide was produced by covering the bulb of the hydrogen thermometer with cotton-wool and dipping it into the liquid. On removing it and blowing air on the surface the liquid froze and the temperature fell, the pressure falling concurrently. The lowest reading of pressure was taken as equivalent to the melting point of the solid. The temperatures thus observed in two experiments were −102·5° and −102·1°; the mean being −102·3°, which may be taken as the fusing point of solid nitrogen monoxide.—*J. Chem. Soc.*, lxiii, 833, June, 1893. G. F. B.

5. *On the Tests for Arsenic.*—In 1851 Fleitmann showed that when a mixture containing arsenic and antimony is added to a solution of caustic alkali and heated, arsine is evolved but no stibine. Hager soon after showed that when the arsenic is in the form of arsenic acid no arsine is evolved under these circum-

stances. In 1873 Gatehouse proposed to replace the zinc by aluminum in Fleitmann's test; and in 1878 Johnston claimed that this process was successful with arsenic compounds. Fresenius confirmed this result later and concedes that the Gatehouse process detects arsenic acid. This subject has now been re-examined by CLARK who concludes from carefully conducted experiments that when arsenic acid is heated with pure aluminum and potassium or sodium hydrate not a trace of arsine is evolved; the result obtained by Fresenius being due apparently either to the presence of a little arsenous acid in his arsenate or to phosphorus. The author tested the suitability of this process for the quantitative determination of arsenic as arsenous acid. But he was unable to convert more than four-fifths of the arsenous oxide into arsine owing to the formation of the solid hydride. Moreover the author finds that the use of sodium amalgam in place of aluminum as proposed by Davy in 1876, does not evolve arsine when the arsenic present is in the form of arsenic acid.

CLARK has also proposed an improvement in Reinsch's test for arsenic. The material to be tested is boiled gently in a porcelain vessel with dilute hydrochloric acid and a strip of copper foil about 1 inch by ¼ inch. When the coating is decided the copper is removed and washed with water and alcohol, and then placed in a mixture of dilute potassium hydrate and hydrogen peroxide and allowed to digest in the cold. The arsenic and antimony are dissolved, and the copper now bright is returned to the organic mixture. The alkaline liquid is heated to boiling, filtered and evaporated to a small bulk. It is washed into a small flask with strong hydrochloric acid, ferrous chloride is added, and the flask being fitted to a worm condenser, the arsenic is distilled into water. Through this distillate hydrogen sulphide is passed; when if more than $0{\cdot}1^{mgrm}$ of arsenic be present a yellow precipitate is obtained. This may be filtered off, washed with CS_2, alcohol and water, dissolved off the filter with dilute ammonia, evaporated to dryness and weighed as arsenous sulphide. According to Curtmann, a yellow coloration is produced by hydrogen sulphide when only $0{\cdot}001^{mgrm}$ of arsenous sulphide is present. The filtrate after removal of the arsine is saturated with hydrogen sulphide, the antimony sulphide filtered off, dissolved in caustic soda, filtered to remove any copper sulphide, and the antimony sulphide precipitated by hydrochloric acid; the precipitate being washed with alcohol, CS_2 and water and weighed as antimonous sulphide. In his arsenic experiments, 0·004, 0·001 and 0·0004 gram of arsenic being taken, 0·0042, 0·0014 and 0·0004 gram were found, the latter estimated by color. In the case of antimony 0·004 and 0·001 being taken 0·0049 and 0·0017 were found. In presence of organic matter 0·004 gram each of arsenic and of antimony were taken; the quantities found being 0·0038 and 0·0042 gram respectively. In a second experiment where 0·001 gram of each was taken the arsenic found was 0·001 and the antimony 0·0009. This sensitiveness appears to be all that is

required for toxical purposes.—*J. Chem. Soc.*, lxiii, 884, 886, June, 1893. G. F. B.

6. *On the Density of Carbon monoxide and the Atomic Mass of Carbon.*—The density of carbon monoxide has been carefully determined by LEDUC. It was prepared by the action of sulphuric acid on oxalic acid and was purified by means of potassium hydroxide and dried over phosphoric oxide. Three mass determinations of a given volume of the gas at 0° and 760^{mm} gave the values 2·8470, 2·8478, 2·8469; the mean being 2·8469. Since the mass of air contained in the same vessel was 2·9440 grams, the relative density of the carbon monoxide is 0·96702; agreeing with the value ordinarily accepted. If at 0°, this gas has the same molecular volume as oxygen, the atomic mass of carbon calculated from the above density is 11·913 (O = 15·88). This value agrees very closely with the numbers 11·915 and 11·917, obtained by synthesis by Van der Plaat and Friedel respectively. Assuming the experimental results to be correct, the ratio of the molecular volume of carbon monoxide to that of oxygen is 1·0001. It has been shown that the corresponding ratio for hydrogen and oxygen is about 1·002. If Regnault's value for oxygen (1·10563) be assumed as true, the atomic mass of carbon would be 11·897, which is not in sufficiently close agreement with the actual determinations. There can be little doubt therefore that the author's value 1·1050, is more correct. Since the relative density of methane calculated from its molecular mass is 0·55376, which is lower than the value generally accepted, it is probable that the determinations were made with a gas not quite pure.—*C. R.*, cxv, 1072; *J. Chem. Soc.*, lxiv, 165, April, 1893. G. F. B.

7. *On the Volatilization of Silica.*—Although pure silica is sometimes observed in the higher portions of blast-furnaces as a sublimate, no direct experiments have ever been made apparently to test its volatility directly. This has now been done by CRAMER, who used pure crystallized native silica for this purpose. A Deville furnace, 12^{cm} in diameter and 33^{cm} high was heated by means of graphitic carbon, a blast of air being forced in from below. After two hours the heat obtained was equal to the highest ever noticed in furnaces, platinum not only being melted but actually beginning to boil and evaporate. A weighed quantity of the crystallized quartz was introduced into a graphitic crucible provided with a lid. This was put inside a second crucible of magnesite, the space between them being filled with powdered magnesia. The whole was now placed in the furnace, a strong blast was applied and after 4 kilograms of graphite had been burned the experiment was stopped and the quartz re-weighed. It was found to have lost 40·5 per cent. After repeating the operation three times the author succeeded in volatilizing the quartz completely. No volatilization however takes place when the temperature is not above that of melting iron.—*Zeit. angew. Chem.*, 1892, 484; *J. Chem. Soc.*, lxiii, 164, June, 1893. G. F. B.

8. *On the Inertness of Quicklime.*—While the activity of calcium oxide toward water is so well known as to give to this substance the name "quicklime," yet to other substances it is in general quite inert. Neither carbon dioxide nor hydrogen sulphide for example will unite with dry quicklime. VELEY has undertaken an investigation to determine how far the absorptive power of lime for gases is dependent (1) upon the mass of water present and (2) upon the temperature. In the first set of experiments carbon dioxide was the gas employed; in the second set sulphur dioxide. The lime was contained in a tared U tube, and the carefully dried gas passed over it. The amount of absorption was determined both by the increase of the weight of the lime and by that of a soda solution placed beyond it; the sum of the two giving the total mass of gas passed. It was observed that the effect of a trace of water is precisely similar to that of heat energy in inducing the combination of ordinarily inert substances. Neither carbon dioxide nor sulphur dioxide combines with dry lime appreciably below 350°; these gases being quite similar in this regard. At ordinary temperatures incompletely hydrated lime does not combine with CO_2; though 10 per cent of water greatly increases the absorption. Neither does ordinary quicklime absorb nitrous fumes.—*J. Chem. Soc.*, lxiii, 821, June, 1893. G. F. B.

9. *Lecture-notes on Theoretical Chemistry.* By F. C. WEICHMANN, Ph.D. 12mo, pp. xiv, 225. New York, 1893 (John Wiley & Sons).—In compiling this little manual the author has evidently intended to offer within a small compass a general review of "the wide domain of chemical theory" including in this term not only chemical theories proper but also the physics of chemistry to a large extent. Hence it contains chapters on Specific gravity, on Solutions, on Energy and on Thermo-, Photo- and Electro-chemistry as well as chapters on Atoms and Valence, on Chemical formulæ, on Chemical equations and on the Periodic Law. While of course these subjects can be treated only very briefly within the space given them, they appear to be clearly presented; so that the student will be prepared for the more extended treatises, a list of which is appended. Mechanically, the book is excellent. G. F. B.

10. *A Guide to Stereochemistry*, based on lectures delivered at Cornell University. By ARNOLD EILOART, Ph.D., B.Sc. 8vo, pp. iv, 106. With 50 woodcuts and 5 plates. New York, 1893 (Alexander Wilson). This brochure is a timely resumé of the evolution of one of the most important subjects occupying the attention of chemists at the present time. Its first 36 pages treat of the Stereochemistry of Carbon and the next 14 of the Stereochemistry of Nitrogen; while the rest of the book is occupied with an Index to the literature of Stereochemistry and a short article on the use of models in teaching solid formulas. The development of the subject is mainly historic. The discussion is clear and, aided by the numerous illustrations, cannot fail to be fully understood by the attentive student. G. F. B.

11. *Heat.* By MARK R. WRIGHT. 12mo, pp. x, 336. New York, 1893. (Longmans, Green & Co.).—This book forms one of the manuals issued for students in advanced classes. It treats the subject from the basis of fact rather than of theory, the nature of heat not being discussed until the second third of the volume. The statements appear accurate and the illustrations good. Radiation is still included as a department of heat proper. Numerous questions and problems are given at the end of the chapters. The subject of Thermodynamics is exceptionally well treated. G. F. B.

12. *A Select Bibliography of Chemistry*, 1492–1802, by H. C. BOLTON. 1212 pp. 8vo, No. 850 of the Smithsonian Miscellaneous collections.—This volume is the result of an immense amount of careful work. Coming from Prof. Bolton, it is sure to be accurate work. Chemists owe him a great debt of gratitude for this "labor of love."

13. *Interferences of electrical waves produced by normal reflection from a metallic plate.*—According to the researches of Hertz, long electrical waves apparently travel faster in air than along wires, while the velocities in the two media are sensibly equal for short waves ($\lambda = 30^{cm}$). MM. Sarasin and de la Rive have instituted experiments on a large scale to test the question of this inequality in the rate of propagation. A building connected with *forces motrices du Rhône* at Geneva was placed at their disposal. A metallic reflecting surface 8^m in height and 16^m in breadth of zinc $\cdot 5^{mm}$ in thickness was placed against a wall of the interior of the building, and a camera-like box 10^m long and $1\cdot 50^m$ wide made of black paper rested against the metallic surface and projected into the room. This dark chamber was supported at such a height that a normal through its center to the metallic surface was 4^m above the floor. A species of optical bank ran through the center of the dark chamber on which the various resonators which were used were mounted.

The apparatus for producing the electric sparks did not differ essentially from that employed by Hertz with the exception that the Ruhmkorf coil was excited by a dynamo machine. The spark apparatus was placed at a height of 4^m and 15^m from the mirror. By moving the resonators to and fro in the dark chamber, points of interference of the direct and the reflected waves were obtained. In one case a resonator of $0\cdot 75^m$ in diameter was employed. It consisted of a hollow tube of copper bent into a circle. The exterior diameter of the tube was 1^{cm}, and one end of the tube was provided with a suitable micrometer in order to measure the spark gap. It was found that a reflecting surface of at least 12^m to 14^m in length and 8^m in height was necessary to produce the phenomena with a resonator $0\cdot 75^m$ in diameter, and a surface 8^m by 8^m to produce them with a resonator $0\cdot 05^m$ in diameter. The author's conclusions are as follows:

The circular resonator responds to a constant wave length, whatever may be the dimensions of the exciter; the intensity

of the secondary spark alone varies, attaining its maximum for a given length of the exciter. One-fourth of the wave length of a circular resonator is approximately equal to twice its diameter.

In the case of normal reflection from a metallic surface the first node is exactly at the mirror.

The velocity of propagation of an electric wave is the same for air and conducting wires.—*Archives des Sciences Physiques et Naturelles*, Troisiéme periode t. xxix, April and May 1893, p. 358–441. J. T.

II. Geology and Mineralogy.

1. *The Geological Society of America.*—The fifth summer meeting of the Geological Society of America was held on Tuesday and Wednesday (Aug. 15 and 16) in the Geological Section Room of the University of Wisconsin. In the absence of the President, Sir Wm. Dawson, the Vice-President, Prof. T. C. Chamberlin presided. Prof. C. R. Van Hise gave an address of welcome.

Papers were read by J. W. Dawson, on the study of fossil plants (read by the secretary); E. W. Claypole three short papers on fishes from the Cleveland shale; J. J. Stevenson, on the Origin of the Pennsylvania anthracite; C. W. Hall and F. W. Sardeson, on the Magnesian series of the northwestern states; C. R. Van Hise, on the Succession in the Marquette Iron district of Michigan; G. F. Wright, on the Extra-moraine drift in New Jersey; A. A. Wright, on the Limits of the glaciated area in New Jersey; J. W. Spencer, on Terrestrial subsidence in the southeast part of the American continent; Warren Upham, Evidence of elevation of Kames, Eskers, and Moraines of the North American ice sheet, chiefly from its englacial drift, and on the Succession of pleistocene formations in the Mississippi and Nelson river basins; N. H. Darton, on the Cenozoic history of Eastern Virginia and Maryland; E. H. Williams, on South Mountain glaciation; H. F. Reid, on the Gravels of Glacier Bay, Alaska; W. P. Blake, on the Dislocations in the strata of the Lead and Zinc Region of Wisconsin, and their relations ot the mineral deposits, with some observations upon the origin of the ores; J. H. Holmes, on the Sand Hill country and the coastal plains of North Carolina; G. H. Williams, on the Geological exhibitions at the World's Fair; (read by title) J. P. Smith, on the Arkansas coal measures in their relation to the Pacific Carboniferous province.

The following notes briefly indicate the contents of some of the papers read:

Prof. J. J. Stevenson, in his paper on the Origin of the Pennsylvania anthracite, described the geological structure of the coal areas of Pennsylvania and their relation to the coal areas of Maryland and the Virginias. He told of the decrease in volatile combustible matter of coals along an east and west line in Pennsylvania as described many years ago. The theory of H. D.

Rogers that the anthracite is due to metamorphic influence of steam and superheated gases escaping from crevices: that of J. P. Lesley that the metamorphism is due to increased earth heat: and the other that the metamorphism is due to transformed mechanical force were examined and in each case found to be unsatisfactory, being either discordant with the facts or unsupported by them. The author maintained that the coal is not due to metamorphism but to longer continuance of the process whereby bituminous coal is formed. Twenty years ago he was led to believe that the great coal marsh, which was the parent of the successive coal beds originated at the east, and after each subsidence advanced seaward once more upon the new deltas. Under such conditions the thickness of coal in the northeast corner of the Appalachian basin, where the deltas formed rapidly, should be very much greater than in any other portion, and therefore the degree of conversion should be greater there than elsewhere. Comparisons of the several groups of the coal measures show that in the anthracite strip the thickness increases northward slowly until beyond the southerly prong of the southern anthracite field; but that the increase is abrupt at that point and soon becomes very great; also that the thickness of coal decreases westwardly as the distance increases from the anthracite region. Comparison of analysis shows that the amount of volatile matter decreases toward the anthracite region, toward the region of greatest thickness of coal; and that the decrease is gradual, even in the anthracite strip, until the thickness increases abruptly. It was shown that the decrease in volatile material has no relation whatever to increase or decrease of disturbance in the rocks: that it is wholly independent of the general composition of the associated rocks: that it is not due to the influence of heat as a metamorphic agent: but that it is due to longer exposure, prior to entombment, to conditions favoring the escape of CH_4.—*Author's abstract.*

Messrs. Hall and Sardeson classified the lower formation of Iowa, Wisconsin and Minnesota, from studies of their own in the field and of the fossils discovered, as follows:

Silurian.

Saint Peter (= Chazy).
Shakopee (Upper Shakopee).

Upper Cambrian.

New Richmond (Elevator B Sandstone).
Oneonta (Lower Shakopee) (= Low. Calcif. of N. Y.)
Jordan Sandstone (= Madison sort).
Saint Lawrence dolomites (= Mendota dolomites).

Middle Cambrian.

Dresbach Sandstone.

They found a Chazy fauna in the Saint Peter; in the Shakopee a peculiar fauna which they were unable certainly to locate in

the Cambrian or Lower Silurian; no fossils in the New Richmond; a common fauna in the Oneonta, Jordan and Saint Lawrence formations. The Oneonta is the basal member of the Magnesian of earlier writers.

The paper by E. H. Williams announced the discovery of a new locality of extra-morainic drift at South Mountain near Bethlehem, Pennsylvania.

A. A. Wright reported the tracing of the boundary of the moraine in New Jersey through Riggleville, Pattenburg (White House), Readington to Somerville.

Prof. G. F. Wright's paper on the Extra-Morainic Drift of New Jersey touched upon the continuity of the deposit from the moraine to the extreme border, and called attention to the need of a revised interpretation of the gravel deposits along the Delaware River. Now that the glacial border is brought down several miles below the mouth of the Lehigh River, the deposits in both rivers above that point heretofore classed with the Philadelphia brick clay and red gravel are seen to be connected with the presence of land ice and must be so interpreted. Below this point the gravel will not bear the sharp discrimination which has heretofore been given it, the Columbia and the Trenton being practically continuous.—*Author's abstract.*

J. W. Spencer, from a study of the topography of the bottom of the ocean and the position of the formation above the level of the sea, in the regions east and south of Florida, concluded that there are numerous deep transverse cañons off shore, and among the islands of the West Indies indicating extensive erosion at a time when the whole region was elevated, 2000 fathoms or more above its present level. His opinion was that the elevation occurred prior to the close of the Miocene, and that between the later Miocene and the present time there was a downward movement of this region.

In discussing the paper W. P. Blake referred to an unpublished fact that there are across Santo Domingo traces of coral reefs along sides of mountains indicating elevation to the amount of 2000 feet since Post-Pliocene began.

In the paper on Evidences of the derivation of the Kames, Eskers, and Moraines of the North American ice-sheet chiefly from its englacial drift, by Warren Upham, the massive kame hills which make up nearly the whole of the terminal moraine known as the backbone of Long Island eastward from Roslyn were shown to have been deposited at the mouths of superglacial or englacial streams, not by subglacial drainage; and other kames and eskers in New York, North Dakota and Manitoba were described, whose features imply their similar origin. In Minnesota and North Dakota the relationship of retreatal moraines to Lake Agassiz indicates likewise their englacial derivation. These examples are regarded by the author as types of the general manner of the transportation and deposition of the materials of kames, eskers, and moraines. The basal currents of the ice-sheet

on the central and greater part of its area are thought to have carried much drift upward from the ground into the lower fourth or third part of the ice, the rate of its ascent being perhaps one or two degrees, which would give a rise of 90 or 180 feet in a mile. During the final melting and retreat of the ice-sheet, its large volume of englacial drift was deposited, partly as ground moraine or subglacial till carried down by descending currents in the outer part of the ice within distances estimated to range from 10 or 20 to 50 or 100 miles back from the ice boundary. Another large part of the englacial drift became exposed on the ice surface by its ablation and fell loosely as the ice melted away, forming the upper part of the till; but much of this superglacial drift was washed away by the glacial streams and deposited as the stratified gravel, sand, and clay, called modified drift.

In a second paper on the Succession of Pleistocene formations in the Mississippi and Nelson River Basins, the Lafayette formation and the Saskatchewan gravels were referred to fluvial deposition during an epeirogenic uplift initiating the Pleistocene period and culminating in the accumulation of the continental ice-sheet. The till and marginal moraines record the maximum extent and stages in the recession of the ice. Lœss and other stratified drift deposits were mostly laid down during the glacial recession, being supplied from englacial drift, as likewise were the deltas of Lake Agassiz for their larger part. Depression of the land during the Glacial period and its reëlevation while the ice-sheet was retreating are well shown by the lœss, the beaches of Lake Agassiz, and marine beds about Hudson Bay. (Author's abstract.)

N. H. Darton in his paper on Cenozoic History of Eastern Maryland and Virginia "gave a brief account of the topography and structure of the region, and of the salient feature of the Cenozoic members, and a summary of the history of a series of deposition intervals and tiltings in the general Cenozoic emergence. The principal feature of the paper was the announcement of the discovery of an erosion interval between the upper and lower Columbia terraces eastward due to tilting from the northwestward during the Columbia uplift. Off to the east and south the later Columbia lies on earlier Columbia, in places beautifully differentiated, in the normal sequence." (Author's abstract.)

H. F. Reid in his public lecture on "Glacier Bay, Alaska," said that Glacier Bay is the most accessible region in which to see large tidewater glaciers. There are eight glaciers which discharge bergs into its waters. The largest of these is Muir Glacier which drains an area of about 800 square miles. It is moving with a maximum velocity of about seven feet a day, and is continually discharging large icebergs from its end. It has extensive gravel deposits which present many interesting features. Its fluctuations have been great within recent times. One or two hundred years ago it extended, in common with the other glaciers of the bay, twenty miles below its present ending; and not long before that, the glaciers were so small, that valleys now barren

and bleak, were occupied by large forests. (Author's abstract.) Mr. Reid afterwards read before the society a more detailed account of the gravels which are exposed in thick deposits standing as abrupt bluffs on the sides of the bays beyond the present position of the glacier front.

In the paper by Prof. Wm. P. Blake upon "Dislocation in the strata of the Lead and Zinc region of Wisconsin and their relations to the Mineral deposits, with some observations upon the origin of the ores," attention was directed to the observations of Percival in that field and their correctness as regards the faulting and also to a direct relation of the faulted areas to the mineral deposits as shown by the author's examination in the Shullsburg region. Reference was made to the recent paper by Prof. Jenney upon faults in the lead and zinc regions of Wisconsin and Missouri in further confirmation, but the author rejects the views of both Percival and Jenney in regard to the upward flow of mineral solutions through the faults, and adopts substantially the views of Prof. Whitney and of Prof. Chamberlin upon the original deposition of the sulphides from sea-water in the mass of the rocks and their subsequent concentration in the fissures and crevices by a downward flow of the solutions due to oxidation; but he directs attention however to the probable influence of the dislocations upon the localization of the deposits; first, by the possible direct outflow of freshwater, or by gases acting as precipitants; and second, by the destruction of organisms and the accumulation of their remains near the faults. He also directed attention to the petroleum shale, a thin layer, known as the "oil-rock" which is generally the floor or bed-rock of the deposits of blende, and upon which this ore usually spreads out and ends. This petroleum, or the gases arising from it, appear to have had more influence in determining the reprecipitation of the sulphides than has hitherto been recognized. The fact that the lead and zinc region is coincident in area with the "driftless area" is regarded as good evidence of the source of the metallic solutions in the mass of the rocks which have decayed by oxidation and long exposure to the elements and have supplied metallic solutions, which have been reprecipitated at lower levels. In conclusion, attention was directed to the world-wide distribution of the ores of lead and zinc in the older limestones and dolomites as evidence of peculiar chemical conditions favoring the precipitation of the ores of these metals from sea-water. (Author's abstract.)

The winter meeting of the Society will be held in Boston, Mass., beginning December 27, 1893, at the rooms of the Boston Society of Natural History. Detailed information regarding the meeting will be sent by the Secretary in due time. H. S. W.

2. *Geological Congress at Chicago.*—At the World's Congress on Geology held in the Memorial Art Palace, Chicago, August 24th, 25th, and 26th, the following papers were read and discussions were held.

On Thursday, August 24th:

O. A. DERBY, of Brazil: The general geology of Brazil.
ADOLPH ERNST, of Venezuela: The general geology of Venezuela.
HENRY HICKS, of England: Pre-Cambrian rocks of Wales.
HENRY M. AMI, Canada: The classification of the rock formations of Canada, with special reference to the Paleozoic era.
A. C. LAWSON: The Cordilleran Mesozoic revolution.
C. W. HALL: The Pre-Paleozoic floor in the Northwestern States.
GEORGE H. WILLIAMS: Distribution of Pre-Cambrian volcanic rocks along the eastern border of the United States and Canada.

After discussion of the above papers, the special discussion for the day was upon the question, "Are there any natural geological divisions of world-wide extent?"

On Friday, August 25:

A. R. C. SELWYN, of Canada: Huronian versus Algonkian.
ALFRED HARKER, England: On the migration of material during the metamorphism of rock masses.
WARREN UPHAM: Wave-like progress of an Epeirogenic uplift.
O. A. DERBY, of Brazil: Eruptive phenomena of Brazil.
W. J. MCGEE: Genetic classification of Geology.
GEORGE F. KUNZ: Precious stones and their geological occurrence.
C. R. VAN HISE: The extent and lapse of time represented by unconformities.
LESTER F. WARD: The Phylogeny of plants.
O. JAEKEL, of Germany: The Phylogeny of the classes of vertebrates.
S. W. WILLISTON: Restoration of Clidastes (illustrated).

After the reading of the papers, the question for the special discussion of the day was, "What are the principles and criteria to be observed in the restoration of ancient geographic outlines?

On Saturday, August 26:

JAMES GEIKIE: Glacial succession in the British Isles and Northern Europe.
HJALMAR LUNDBOHM, of Sweden: Glacial succession in Sweden.
ROBERT BELL, of Canada: The succession of the Glacial deposits of Canada.
T. C. CHAMBERLIN: Glacial succession in the United States.
WARREN UPHAM: Pleistocene climatic changes.
FRANK LEVERETT: Evidences of the diversity of the older drift in northwestern Illinois.

The special discussion for the day was upon the question, "What are the principles and criteria to be observed in the correlation of Glacial formations in opposite hemispheres?

H. S. W.

3. *Geological Time.*—Prof. C. D. Walcott, in his address before the Geological Section of the American Association on "Geological Time as indicated by the Sedimentary Rocks of North America," gave the following estimates of the length of time required for the formation of the grander divisions of sedimentary rocks.

For the Cenozoic, including Pleistocene, 2,900,000 years; the Mesozoic, 7,240,000 years; the Paleozoic, 17,500,000; the Algonkian, 17,500,000; the Archæan?

4. *Annual Report, for* 1892, *on the Geological Survey of Texas, under* E. T. DUMBLE.—The following parts of this fourth Annual Report of the Texas Geological Survey have recently been issued.

(1) A preliminary report on the Vertebrate Paleontology of the Llano Estacado by E. D. COPE. 88 pp. 8vo, with 23 plates.

May, 1893. The vertebrate fossils described and figured are from the Dockum Terrane of the Triassic, the Loup Fork beds, the Blanco beds, and the Equus beds. They represent nearly fifty species.

(2) Preliminary Reports on the Artesian Wells of the Gulf coastal slope, by I. A. SINGLEY; and on the organic remains from the deep well at Galveston, by GILBERT D. HARRIS. 34 pp. June, 1893. The Galveston well is that which is the subject of the paper at page 38 of this volume.

(3) A contribution to the Invertebrate Paleontology of the Texas Cretaceous, by F. W. CRAGIN. 106 pp., with 13 plates.

(4) Report on Grimes, Brazos, and Robertson Counties, by W. KENNEDY. 84 pp., with sections. June, 1893.

(5) Report on the Rocks of Trans-Pecos Texas, by A. OSANN; and on the Geology of Trans-Pecos Texas, by W. H. STREERUWIRTZ. 54 pp. July, 1893.

5. *Geological Survey of New Jersey. Gasteropoda and Cephalopoda of the Raritan Clays and Greensand Marls of New Jersey*, by R. P. WHITFIELD. 402 pp. 4to, with 50 plates. Trenton, N. J., 1892.—The first part of Mr. Whitfield's very valuable Report on the Cretaceous and Tertiary fossils of New Jersey, treating of the Lamellibranchiata, is now followed by a second part, of like importance and excellence. These volumes are ix and xviii in the quarto publications of the U. S. Geological Survey.

6. *Annual Report of the Director of the U. S. Geological Survey*, vol. XI. Part 1, Geology, 750 pp. roy. 8vo; Part 2, Irrigation, 396 pp.; each with maps and other illustrations.—The memoirs included in Part 1, are the following: "The Pliocene History of northwestern Iowa, by W. J. McGEE, occupying 380 pages—which has already been noticed in this Journal; and the Natural Gas field of Indiana by A. J. PHINNEY, 126 pp., with an introduction of 28 pp. by W. J. McGEE.

7. The following Bulletins and quarto Memoirs of the United States Geological Survey have been recently issued:—

Bulletin No. 85. Correlation Papers: The Newark System, by I. C. RUSSELL. 344 pp., 8vo, with maps.

No. 86. Correlation Papers: Archean and Algonkian, by C. R. VAN HISE. 549 pp., with maps.

No. 90. Report of work done in the division of Chemistry and Physics, mainly during the fiscal year, 1890–91, by F. W. CLARKE. 75 pp.

No. 91. Record of North American Geology for 1890, by N. H. DARTON. 88 pp.

No. 92. The compressibility of Liquids, by CARL BARUS. 96 pp., with plates.

No. 93. Some Insects from Florissant, Colorado, and from other points in the Tertiaries of Colorado and Utah, by S. H. SCUDDER. 35 pp., with plates.

No. 94. The mechanism of solid Viscosity, by CARL BARUS. 138 pp., with figures.

No. 95. Earthquakes in California in 1890 and 1891, by E. S. HOLDEN. 29 pp.

No. 96. The Volume Thermodynamics of Liquids, by CARL BARUS. 100 pp., with plates.

Memoir Vol. XVII. The Flora of the Dakota Group, a posthumous work by Leo Lesquereux, edited by H. H. Knowlton. 400 pp. 4to, with 66 plates.

8. *The Seismological Journal of Japan:* edited by JOHN MILNE, F.S.S. Vol. I, 1893.—This Journal succeeds to the publications of the Seismological Society, this society having ceased to exist. This volume corresponds to vol. xvii of its Transactions. As Japan is extraordinary as regards frequency of earthquakes, and also their violence, its Seismological Observatory and 700 outside stations are capable of more thorough investigation in this department than is elsewhere possible. The work already done has produced, for future investigators, new seismographs giving absolute measurements of earth-motions, and has led to the application of principles for the mitigation of the effects of earthquakes on buildings, besides advancing seismological science in other ways. This volume of 150 pages contains various papers of value by Mr. Milne, and others by Prof. W. K. Burton, and F. Omori.

9. *Bulletin of the Geological Institution of the University of Upsala*, edited by HJ. SJÖGREN. No. 1, Vol. I, Upsala, 1893. 95 pp. with 5 plates.—This new publication, of which the first number has recently appeared, is designed as a medium for the issue of original investigations made at the University of Upsala. The leading and longest article (pp. 1–64) is entitled Contributions to Swedish Mineralogy by Hj. Sjögren and contains the results of his observations upon the species of the humite group from Sweden, also on svabite, adelite, etc. Other articles, chiefly geological, are by Wiman, O. Nordenskiöld, Anderson, etc.

10. *Traité des Gîtes Minéraux et Métallifères; recherche, étude et conditions d'exploitation des mineraux utiles, description des principales mines connues, usages et statistique des Métaux.* Cours de Géologie Appliquée de l'École supérieure des Mines; par ED. FUCHS, Ingénieur en chef des Mines, Professeur à l'Ecole supérieure des Mines, et L. DELAUNAY, Ingenieur au Corps des Mines, Professeur à l'Ecole supérieure des Mines. Paris, 1893 (Baudry et C^ie^). Large 8vo, vol. i, 823, pp., vol. ii, 1015 pp. with many maps and illustrations.—This treatise of over 1800 octavo pages, on useful minerals and ores, their distribution, modes of occurrence, methods of origin, and the industrial subjects connected with them and their exploration, is an admirable work. After an introduction of 110 pages, consisting of an alphabetic list of localities, a table giving the geographical distribution of localities over the globe, and tables for the conversion of French and foreign weights and measures and coins,

the treatise commences with Carbon, under which, the subject of the Diamond covers near 50 pages; and then follow, with full details, the subjects of natural gas, petroleum, bitumen and other hydrocarbons, carrying the work to the 220th page. Like fulness as to details characterizes the whole work. Besides descriptions, the work contains a large number of maps of the mineral regions, several of them giving the geological formations; and among these there is a colored geological map of the United States (from Hitchcock's), a map of the petroleum region of western Pennsylvania, one of the Comstock and another of the Eureka region in Nevada, another of the Leadville region, each of these, large and fine detailed maps, with sections and plans of workings. In like manner the various localities of mines and useful minerals of other countries are illustrated. The work was prepared for the course of applied geology at the École des Mines, at Paris, instituted in 1879 by Prof. Fuchs; and it is well adapted for use in such courses elsewhere.

11. *The Glacialists' Magazine: A Monthly Magazine of Glacial Geology, embodying the Proceedings of the Glacialists' Association.* Edited by PERCY F. KENDALL, F.G.S. and Secretary of the British Association Committee on Erratic blocks; assisted by WARREN UPHAM, C. E. DERANCE, President of the Glacialists' Association, and J. LOMAS, A.R.C.S.—This first number of the Glacialists' Magazine, covering 30 pages, contains, besides various notes on Glacial subjects, the Presidential Address of the Glacialists' Association, C. E. DeRance, and a discriminating review of Howorth's "Glacial nightmare and the Flood." The magazine, as its editorial corps indicates, will be a valuable Journal for the American as well as European side of the Atlantic.

12. *Mount Loa, Hawaii.*—An ascent of Mt. Loa was made by Rev. E. P. Baker on the 24th of June last. At the summit, the only action to be seen in the summit crater was the escape of vapor, great volumes of which arose from the central area, the same from which it issued from 1885 to the time of the eruption in 1887. At the time of his visit to the crater in February 1887, and again in 1888, there was a small crater in the floor of the great central crater near its southwest corner. This small crater was in existence in 1889, when the crater was visited by Mr. Thurston. But nothing was now to be seen of it; lavas had filled it, making the floor continuous over the place. Its outline only was partially distinct at two or three points in its circumference. —*Letter from Mr. Baker, dated Hilo, July* 5, 1893. According to an earlier letter from Mr. Baker, on November 30 and December 1 and 2 of 1892, a light was seen at the top of the mountain from below, indicating the presence in the bottom of the crater, as his letter states, of molten lava; and this may have been the time of the occurrence mentioned above.

13. *Brief notices of some recently described Minerals.*—NEPTUNITE and EPIDIDYMITE are two new species described by G. Flink from the neighborhood of Julianehaab on the Kangerdluarsuk

in Greenland. They occur with ægirite, arfvedsonite, eudialyte, etc., the association being similar to that of Langesund in Norway.

Neptunite occurs in short prismatic crystals, belonging to the monoclinic system, and shows perfect cleavage parallel to the fundamental prism of 99° 46′. The hardness is between 5 and 6 and the specific gravity 3·234. The color is black, but deep red-brown in very slender crystals. An analysis gave:

SiO_2	TiO_2	FeO	MnO	MgO	K_2O	Na_2O
51·53	18·13	10·91	4·97	0·49	4·88	9·26=100·69

For this the formula proposed is:

$$(\tfrac{3}{4}Na_2+K_2)Si_4O_9+(\tfrac{2}{3}Fe+\tfrac{1}{3}Mn)TiO_3.$$

Epididymite, as is suggested in the name, is near the eudidymite of Brögger and is regarded as a dimorphous form of the same compound. It is found in orthorhombic crystals prismatic in the direction of the macrodiagonal, and pseudohexagonal in angle, which character is also shown in its twinning. The angles and axial ratio are not far from those of eudidymite, which, however, has been referred to the monoclinic system. The composition is the same, namely: $HNaBeSi_3O_8$. An analysis gave:

	SiO_2	BeO	Na_2O	H_2O
Sp. Grav.=2·548	73·74	10·56	12·88	3·73=100·91

—*Geol. För. Förh.*, xv, 195, 1893.

14. Hautefeuillite is a hydrated phosphate of magnesia and lime from the apatite mines of Bamle, Norway, described by L. Michel. It occurs in lamellar masses having a radiated structure and made up of minute monoclinic crystals elongated vertically and flattened parallel to the clinopinacoid. The hardness is 2·5, the sp. gravity 2·435 and it is colorless and transparent. The analysis gave:

P_2O_5	MgO	CaO	H_2O
34·52	25·12	5·71	34·27=99·62

This corresponds to the formula $(Mg,Ca)_3P_2O_8+8H_2O$, which brings it near bobierrite. The name is given in honor of M. Hautefeuille.—*Bull. Soc. Minn.*, xvi, 38, 1893.

15. Melanostibian is an imperfectly investigated mineral from the manganese mine, Sjögrufvan, in Örebro, Sweden; it is described by L. J. Igelström. It occurs in massive form either with foliated structure forming thin veins, or in microscopic crystals for which the tetragonal or orthorhombic system is suggested. The hardness is 4, the color black, and it is opaque with metallic luster. An analysis (assuming the iron and manganese present as protoxides and the antimony as Sb_2O_3) gave:

Sb_2O_3	FeO	MnO	CaO	MgO	H_2O
37·50	27·30	29·62	1·97	1·03	1·06=98·48

—*Zeitschr. f. Kryst.*, xxi, 246, 1893.

16. *Snow Crystals.*—A recent paper by G. Nordenskiöld gives the preliminary results of an investigation in the winter of 1892–93 of the forms of snow crystals. The discussion of general conclusions is deferred for a later article, but the results as given show a much higher degree of complex character than has ordinarily been assumed. The crystals are divided into two groups according as the development is in the direction of the vertical axis or tabular, and several varieties are noted under each. The paper is illustrated by 20 excellent photo-plates showing many types of forms; most of the crystals are magnified several diameters.—*Geol. För. Förh.*, xv, 146, 1893, and *Bull. Soc. Min.*, xvi, 59.

17. *Repertorium der mineralogischen und krystallographischen Literatur von Anfang d. J.* 1885, *bis Anfang d. J.* 1891; *und Generalregister der Zeitschrift für Krystallographie und Mineralogie*, Band xi–xx. Herausgegeben und bearbeitet von P. Groth und F. Grünling. II Theil. 287 pp. 8vo. Leipzig, 1893 (W. Engelmann).—The second part of this important work (see this Journal, May, 1893, p. 442) has recently been issued. It contains the topical index by Dr. Grünling to volumes xi to xx of Groth's Zeitschrift für Krystallographie und Mineralogie.

III. Miscellaneous Scientific Intelligence.

1. *American Association for the Advancement of Science.*—The forty-second meeting of the American Association was held at Madison, Wisconsin, from the 16th to the 22d of August; about three hundred members registered. The President of the meeting was Prof. William Harkness of Washington. The Vice-Presidents, with the subjects of the addresses delivered by them before their respective sections, are as follows:

A, Mathematics and Astronomy—C. L. Doolittle, of South Bethlehem, Pa., on Variations of Latitude.

B, Physics—E. L. Nichols, of Ithaca, N. Y., on Phenomena of the Time Infinitesimal.

C, Chemistry—Edward Hart, of Easton, Pa., on Twenty-five Years' Progress in Analytical Chemistry.

D, Mechanical Science and Engineering—S. W. Robinson, of Columbus, Ohio, on Recent Advances in Mechanical Science.

E, Geology and Geography—Chas. D. Walcott, of Washington, D. C., on Geologic Time as Indicated by the Sedimentary Rocks of North America.

F, Zoology—Henry F. Osborn, of New York, N. Y., on The Rise of the Mammalia.

G, Botany—Charles E. Bessey, of Lincoln, Neb., on Evolution and Classification.

H, Anthropology—J. Owen Dorsey, of Tacoma Park, Md., on the Biloxi Indians of Louisiana.

I, ECONOMIC SCIENCE AND STATISTICS—William H. Brewer, of New Haven, Conn., on The Mutual Relations of Science and Stock Breeding.

The address of the retiring President, Professor Joseph LeConte of Berkeley, California, upon the Origin of Mountains, was delivered Thursday evening, August 17th.

Saturday was devoted to excursions to several points in the vicinity of Madison, no long excursions being undertaken because of the Scientific Congresses at Chicago, which followed the Association.

Upon the recommendation of the Geological Section, a standing committee on recording and classifying fossil faunas and floras was appointed by the Association, consisting of Henry S. Williams (chairman), Henry F. Osborn (secretary), Chas. D. Walcott, Saml. H. Scudder and Arthur Hollick, with power to add to their number..

The Association elected, as its president for the next meeting, the anthropologist, Dr. D. G. BRINTON, of Media, Pa.; and as officers of Section E, Prof. SAMUEL CALVIN, of Iowa City, Iowa, vice-president, and Prof. W. M. DAVIS, of Cambridge, Mass., Secretary. The meeting will be held in August, 1894; and it is understood that its place, though not decided upon, will be some city in the Eastern States.

List of papers accepted for reading.

Section A. Mathematics and Astronomy.

FRANK H. LOUD: A construction for the imaginary points and branches of algebraic loci.

ALEX. S. CHRISTIE: Upon the latitude variation tide.

E. W. HYDE: The screw as a unit in a Grassmannian system of the sixth order.

ALEX. MACFARLANE: Applications of the generalized logarithmic theorem.

L. E. DICKSON: On the inscriptions on regular polygons.

C. L. DOOLITTLE: Latitude determination at Bethlehem, 1892–93.

GEO. C. COMSTOCK: A determination of the constant of aberration by a modified form of the Loewy method.

MANSFIELD MERRIMAN: On the possibility of the algebraic solution of the general equation of the fifth degree.

S. S. LAWS: Space.

Section B. Physics.

E. W. MORLEY and WM. A. ROGERS: Application of interferential methods to measurements of expansion of long bars.

W. A. ROGERS: A preliminary study of the constants of the Morley interferential comparator. On the effect of evaporation upon the relative dimensions of bars of metal partially submerged in water.

ALEXANDER MACFARLANE: On physical addition or composition.

G. S. MOLER: Some rapid changes of potential studied by means of a curve-writing voltmeter.

E. L. NICHOLS: Some applications of electric heating in physical laboratory practice. Note on the surface tension of liquids.

E. L. NICHOLS and G. S. MOLER: An apparatus for the generation of oxygen and hydrogen by electrolysis.

ERVIN S. FERRY: Note on the use of a rotating disk in photometry.

F. BEDELL, K. B. MILLER and W. F. WAGNER: Irregularities in alternate current curves.

FREDERICK BEDELL: Experiments with an alternate current condenser.

J. O THOMPSON: On the elasticity of metals. Fatigue in the elasticity of stretching.

A. MACFARLANE and G. W. PIERCE: The elastic strength of solid, liquid and gaseous dielectrics.

W. S. FRANKLIN and L. B. SPINNEY: Elastic properties of glass.

W. LECONTE STEVENS: On so-called negative lightning.

E. W. MORLEY: An automatic Toepler pump.

JOHN S. SHEARER: The effect of temperature and of electric driving on the period of tuning forks.

B. W. SNOW: On the continuous spectrum of the alkalies.

JOHN DANIEL: Electrolytic polarization.

Section C. Chemistry.

E. W. MORLEY: On the atomic weight of oxygen.

W. E. STONE: The acetyl and benzoyl derivatives of the pentoses.

W. E. STONE and H. N. MCCOY: The electrolytic oxidation of glycerol.

W. R. ORNDORFF and JOHN WHITE: The constitution of paraldehyde and metaldehyde.

W. A. NOYES: On the nitrites of some amines. Natural gas from New Lisbon, Ohio.

P. C. FREER: The action of sodium on acalone.

P. W. SHIMER and S. K. RIEFSNYDER: Some experiments on sampling by quartation.

L. KAHLENBURG and H. W. HILLYER: Solubility of lead oxide in the normal tartrates and other organic salts with observations on the rotary power of the solutions thus obtained.

T. B. STILLMAN: The analysis of lubricating oils containing "blown" rape-seed and "blown" cotton-seed oils.

G. B. FRANKFORTER: Narceine, a new formula and new derivatives. The structural formula for narceine and its synthesis form narcotine pseudo-norceine.

E. GOLDSMITH: A tempered steel meteorite.

W. L. DUDLEY: The action of gaseous hydrochloric acid and oxygen on the platinum metals. The electro-deposition of iridium: a method of maintaining the uniform composition of an electroplating bath without the use of an anode.

E. G. SMITH: On the occurrence and distribution of nitrogen in deep artesian wells of the Mississippi Basin.

E. H. S. BAILEY and E. C. FRANKLIN: The advantages of extended examinations of river waters.

G. HINRICHS: On the systematic errors affecting all the atomic weights of stars. On a review of atomechanics.

L. ANDREWS: An unusual form of calcium glycerate.

Section D. Mechanical Science and Engineering.

S. W. ROBINSON: Improved form of transmission dynamometer.

J. BURKITT WEBB: Economical compression in a steam engine.

D. S. JACOBS: Experimental determination of the quickness of action of a shaft governor. Tests of automatic fire sprinklers. An accurate method of measuring heavy liquid pressure.

C. WELLMAN PARKS: A mechanical index.

HUPFEL, GRISWOLD and KENNEDY: Test of plant of the Hygeia Ice Company of New York City.

WM. A. ROGERS: On the changes in the dimensions of metals which may be due to changes in molecular structure depending on their age.

Section E. Geology and Geography.

H. F. REID: Gravels of Glacier Bay, Alaska, with lantern illustrations.

JOHN J. STEVENSON: Use of the name "Catskill."

J. A. HOLMES: Section across the coastal plain region in southern North Carolina.

WILLIAM HALLOCK: Notes on further observations of temperature in the deep well at Wheeling, W. Va.

ARTHUR HOLLICK: Recent investigations in the Cretaceous formation on Long Island, N. Y. Northward extension of the yellow gravel in New Jersey, Staten Island, Long Island and eastward.

C. R. VAN HISE: Character of folds in the Marquette iron district.

E. W. CLAYPOLE: The fossil sharks of Ohio.

HORATIO P. PARMELEE: Hillsdale county geology.

CHAS. D. WALCOTT: Exhibition of tribolites showing antennæ and legs.

JOSEPH F. JAMES: Remarks on genus *Arthrophycus* Hall. On the value of pseudo-algæ as geological guides. Studies in problematic organisms. The genus *Fucoides*.

T. C. CHAMBERLIN: Some questions respecting glacial phenomena about Madison.

D. F. LINCOLN: Amount of glacial erosion in the Finger Lake region of New York.

F. P. GULLIVER: Ice-sheet on Newtonville Sandplain.

G. FREDERICK WRIGHT: Additional facts bearing on the question of the unity of the Glacial Period.

FRANK LEVERETT: Changes of drainage in Rock River basin in Illinois.

W. J. MCGEE: Graphic comparison of post-Columbia and post-Lafayette erosion.

R. D. SALISBURY: An illustration of the effect of stagnant ice in Sussex Co., N. J. A phase of superficial drift.

WARREN UPHAM: Tertiary and Quaternary stream erosion of North America.

T. C. HOPKINS: The emergence of springs.

Section F. Zoology.

C. V. RILEY: Notes on Aspidiotus perniciosus. Erastria scitula, a valuable insect to introduce into America. Sphida a myth.

J. B. SMITH: Seat of life in the house fly.

S. H. GAGE: The respiratory mechanism in the lamprey.

L. O. HOWARD: The correlation of structure and host-habit in the Encyrtinæ.

H. F. OSBORN: The mammals of upper Cretaceous.

THEOBALD SMITH: The production of races and varieties of bacteria in mixed cultures. A new sporozoon in the intestinal villi of cattle.

H. G. HUBBARD: The insect guests of the Florida land tortoise.

W. S. MILLER: A comparative study of the lung, with special reference to the communication of one air-sac with another.

J. H. PILLSBURY: Some new revelations regarding color sense in the human retina. On a new apparatus for measuring the strength of color sense.

Section G. Botany.

G. F. ATKINSON: Photography as an instrument for recording the microscopic characters of micro-organisms in artificial cultures. Symbiosis in the roots of Ophioglosseæ. Comparative study of the structure and junction of the sporangia of ferns in the dispersion of spores.

B. T. GALLOWAY: Observations on a rust affecting the leaves of the Jersey or Scrub Pine. Results of some recent work on rust of wheat

W. J. BEAL: Prophylla of Gramineæ.

J. CHRISTIAN BAY: A new injection needle for the study of lower plants. The bibliography of American botanical literature.

C. R. BARNES: On the food of green plants.

BYRON D. HALSTED: The Solandi printing applied to botanical work. The shrinkage of leaves in drying.

N. L. BRITTON: Present aspects of the nomenclature question. A consideration of a species based upon a theory of evolution.

T. A. WILLIAMS: Lichens of the Black Hills.

D. H. CAMPBELL: Notes on the development of Marattia Douglasii.

JOHN G. JACK: The fructification of Juniperus.

M. B. THOMAS: The roots of orchids.

THEOBALD SMITH: Further observations on the fermentation tube with special reference to anærobiosis, reduction, and gas production.

ERWIN F. SMITH: Two new and destructive diseases of Cucurbita.

CONWAY MCMILLAN: Preliminary statement concerning botanical laboratories and instruction in American universities and colleges.

J. H. PILLSBURY: On the quantitative analysis of the colors of flowers and foliage.

S. G. WRIGHT: The minute structure and development of the motile organ in the leaf of the red-bud.

S. M. TRACY: Distribution of the Gramineæ in the United States.

ELIZABETH G. BRITTON: A revision of genus *Physcomitrium*. On *Ulota Americana* Mitten and *Orthotrichum Americanum* Beauv.

J. C. ARTHUR: Deviation in development due to the use of unripe seeds.

W. T. SWINGLE: The principal diseases of citrous fruits now being studied at Eustis, Fla. *Cephaluros mycoidea* and *Phyllosiphon* sp., two parasitic algæ new to North America.

V. COVILLE: An analysis of the conditions affecting the distribution of plants.

P. H. ROLFS: A Sclerotium disease of plants.

L. H. PAMMEL: Notes on *Rœstelia pyrata*. Crossing of Cucurbita. A case of poisoning by the wild parsnip, *Cicuta maculata*. Preliminary notes on some chromogenic bacteria of the Ames flora.

Section H. Anthropology.

WASHINGTON MATTHEWS: Songs of sequence of the Navajos. [Illustrated by the phonograph.]

H. C. MERCER: The result of excavations at the ancient argillite quarries, recently discovered near the Delaware river on Gaddes Run. Another ancient source of jasper blade material east of the Middle Alleghenies.

C. STAINLAND WAKE: Indian migrations.

W. H. BREWER: The instinctive interest of children in bear and wolf stories.

E. H. S. BAILEY: The delicacy of the sense of taste among Indians.

H. I. SMITH: Caches of the Saginaw Valley.

J. N. B. HEWITT: Is the polysynthesis of Duponcean characteristic of American Indian languages.

A. F. CHAMBERLAIN: Primitive woman as a poet. Some drawings by Kootenay Indians.

J. JASTROW: Psychology at the World's Fair.

H. N. RUST: Some account of a purification ceremony and a sacred stone in use among the mission Indians of California. The Indian stone Adzes. Some facts concerning the obsidian blades called swords, from northern California.

ERNEST VOLK: Observations in regard to the use of argillite by prehistoric people, made by explorations of ancient village sites in the Delaware Valley.

G. F. WRIGHT: The evidence of glacial man in America.

W. J. MCGEE: The antiquity of man in America.

A. S. HERRERA: The prehistoric man of Mexico.

J. F. SNYDER: Buried deposits of hornstone discs.

W. E. MYER: A Shawnee town and its exploration.

W. K. MOOREHEAD: Remarks upon sheet copper designs from the Hopewell group, Ohio.

G. A. DORSEY: The ancient necropolis of Ancon, Peru. Notes for an archæological study of La Plata Island, Ecuador. A ceremony of the Quichua Indians of Peru.

D. G. BRINTON: Remarks on the Mexican Calendar System.

W. H. HOLMES: Theory of primal shaping arts.

J. O. DORSEY: Indian names for the Four Winds and Four Quarters.

C. A. HIRSCHFELDER: The sacrifice of the white dog.

M. M. SNELL: The relation between Mythopeia and Euhemerism.

ADA M. KING: Revision of calendar.

Section I. Economic Science and Statistics.

MANLY MILES: Surface tension of water and evaporation with experiments. Energy as a factor in nutrition.

LAURA O. TALBOTT: The utility of practical psychology. Geneo-pathological chart.

W. J. BEAL: Manual labor at agricultural colleges.

RICHARD COLBURN: The maturing Pacific railroad debts.

HENRY FARQUHAR: Relations of production and price of silver and gold.

H. F. J. PORTER: The necessity for a bureau of record and reference.

2. *The Physical Geography of Antarctica.*—The following paragraphs are from a notice of Dr. Karl Fricker's paper on "Die Entstehung und Verbreitung des antarktischen Treibeises," in the London Geographical Journal for September.

The sources of polar ice are in the main three—snow or glacier ice, fresh-water ice, and sea-water ice, with the possible addition of a fourth, the coast ice or ice foot; and, inasmuch as the relative importance of these is determined both directly and indirectly through the influence on climate, by the geographical distribution of land and sea, the south polar regions present, so far at least as is known, an almost complete contrast to the north. The northern hemisphere has a polar sea, enclosed by a polar continent except for at the most four or five openings, of which only two—Davis Strait and the channel between Iceland and Norway—are of real moment in the movement or distribution of ice, while the southern hemisphere has a polar continent surrounded by a polar ocean, to which a number of islands contribute a quite negligible fraction of the total ice. The supposed Antarctic continent has been touched by explorers in three distinct regions—Enderby Land and Kemp Land in 40° to 60° E. longitude, Wilkes Land and Victoria Land 100° to 170° E. longitude, and Graham Land and Alexander I. Land, with a number of detached islands (for which Dr. Fricker proposes the name Gerritsz Archipelago) to the south of Cape Horn—and in each case it has been found to present an almost unbroken sheet of ice, varying in thickness and formation with the configuration of the land, which extends outwards from the coast and terminates in precipitious ice-cliffs, the great ice barrier.

The conditions giving rise to the formation of an ice-cap of such dimensions are chiefly, of course, those of climate, and of these our knowledge is as yet wofully meagre. Theory, as at present developed, requires a polar area of low barometric pressure—a uniform gradient downward from all sides—and a belt of westerly winds with a central calm area; and for comment we have only a few sets of observations taken during the summer months, none of which extend over more than a few weeks in one place. But so far as they go, the observations almost directly traverse the theoretical hypotheses. They indicate in the first place a zone of low pressure in about 75° S. latitude, with higher barometer further south. Hann suggests that this trough is due to the passage of moving cyclones; but the supposition is not borne out by the wind observations, which show an overwhelm-

ing majority in favor of points between S. and N.E. Since the air temperature over the continent cannot, even in summer, much exceed the freezing-point on account of the ice covering, it seems not unreasonable to suppose as an alternative that pressure continues to increase with latitude after the 75th parallel, and that the southerly and easterly winds are the overflowing currents from a permanent polar anti-cyclone. It was to be expected *à priori* that a theory founded on the assumption of a homogeneous land or sea surface would require modification in the circumstances, and the vertical height of the supposed anti-cyclone need not be sufficient to interfere with upper currents; it might in fact rest as a cushion on the land surface almost independent of the general circulation.

Granting the existence of the polar anti-cyclone, it is not difficult to imagine that the moist warm air ascending from the low-pressure zone moves southward and feeds the anti-cyclone, discharging large quantities of moisture as snow and sleet, and also in the form of crystals deposited from mist, as the temperature is reduced by the ice sheet; and since the supply of vapor is greatest during the more open season in the low-pressure belt, it seems likely that precipitation is greatest during summer. Such climatic conditions are fully sufficient to account for the presence of glacier ice in almost unlimited quantity, provided we assume the existence of continental land, an assumption strongly supported by our knowledge of the Arctic regions, the negative evidence of Grant's Land and the positive of Franz Joseph Land being specially pertinent.

Glaciers of the valley of Alpine type are found on the most stupendous scale. Ross describes one on the east coast of Victoria Land as filling a valley bordered by mountains 6000 to 10,000 feet in height, and sending a tongue far into the sea. But the distinctive feature is the inland ice, known as yet only by the insurmountable cliffs facing the sea. This barrier is remarkable for the uniformity of height it retains for long distances. From the volcanoes Erebus and Terror, Ross traced it eastward for 250 miles, and gives the narrow limits of 150 to 200 feet, Wilkes gives for other parts 150 feet, d'Urville 100 to 150 feet, and Biscoe 100 to 120 feet; in Grahamsland, on the other hand, only 12 to 14 feet is stated. Again, the barrier-ice is noted by the absence of detritus, or moraine material of any kind.

The stormy weather of the southern ocean, and the strength of the tidal streams are in themselves almost sufficient to prove that the barrier-ice is not field-ice formed at sea, but essentially inland ice, and of this further evidence may be derived from its structure. Wilkes, Webster, d'Urville, and in particular the *Challenger* Expedition, give information derived from the examination of icebergs, and agree in describing the ice as of a stratiform structure, their blue layers of hard ice alternating with thicker beds of white soft ice enclosing air, the latter thicker and softer near the top of the ice, and the former preponderating in the lower strata.

Similar formations have been observed by Nansen and Payer, and the presumption is that the soft strata represent snow fallen during winter, and the hard a surface partially melted during the warmer months and re-frozen. Under great pressure the whole mass is gradually converted into homogeneous hard blue ice.

Concerning the several motions of the inland ice, we are without information of any kind. Of the various computations as to its mean thickness, Dr. Fricker adopts that of Thomson—1400 feet.

According to Heim, there are four possible agencies tending toward the dissolution of glacier ice—melting from above, melting from below, internal melting, and the breaking away of drift ice. From the considerations stated above it appears that Antarctic glaciers are chiefly exposed to the second and last of these, the action of warm water eating away the under surface, and the separation of enormous icebergs. Under the most moderate estimates, Dr. Fricker calculates that a minimum of 258,000,000,000 cubic metres of ice are annually detached from the ice barrier and set adrift. The subsequent wanderings of these bergs are chiefly controlled by the ocean currents, although the direct influence of wind is considerable; and the normal "northern limit of drift-ice" is of special interest from the amount of information relating to currents which can—due caution being exercised—be obtained from it. Taken generally, the set of the currents corresponds in direction to the prevailing winds, from south toward north, northwest and west. To this rule there are, however, important exceptions. A comparatively strong easterly current prevails to the south of Cape Horn, probably because of the strong development of west-wind drift to high latitudes in the South Pacific, and the contraction of Bransfield Strait. Again, the motion of the streams becomes extremely involved in the two cases where the coast trends north and south, east of Gerritsz Land and Victoria Land, in part probably simple tidal, and in part "compensation currents" flowing southward. Neumayer to the contrary notwithstanding, Dr. Fricker admits the existence of only one true southerly current—to the south of Kerguelen—and of this he proposes an extremely ingenious explanation. Kerguelen and Head Island are connected by a range of submarine mountains some 240 miles in length, which rises to within 100 fathoms of the surface. Assuming that the westerly drift current extends below this depth, on meeting the obstacle it will divide and a part will be deflected in a south-southeasterly direction, and will to some extent retain that direction by virtue of its superiority in speed over the currents of higher latitudes. The other section of the current, deflected northward, may account for the bend of isothermal lines in that direction observed in the vicinity of Kerguelen.

The general northward tendency of the surface currents, taken along with the known presence of Antarctic water in the lower depths of the oceans of the southern hemisphere, raises a ques-

tion of considerable difficulty as to the nature of the return or compensation current. Dr. Fricker offers a solution of the problem, based on the temperature observations of the *Challenger* and the *Gazelle*, which concur in showing a stratum of relatively warm water at depths between 700 and 900 fathoms in all oceans. The bottom water, moving slowly northward, is ultimately stopped and forced to ascend (the phenomena are naturally most fully developed in the Indian Ocean), its temperature greatly raised, and finally its density so increased by evaporation that it sinks to a position of equilibrium at an intermediate depth and flows southward, tending at the same time eastward through the Earth's rotation as a warm current. On regaining the Antarctic regions the water of this intermediate current is in part absorbed in the formation of ice, and the remainder being thereby increased in density sinks to the bottom and begins its slow return northward.

3. *Prodromus Faunæ Mediterraneæ*, of JULIUS VICTOR CARUS of Leipzig, vol. ii, Part III, Stuttgart, 1893 (E. Schweitzenbart'shce Verlagshandlung).—This new part of volume ii, treats of the Vertebrata, and concludes this very important Prodromus on the Fauna of the Mediterranean. Something of the value of the work may be gathered from the fact that the index of species occupies more than 100 pages, and is independent of an Index of common names covering 30 pages.

4. *Bulletin of the Geographical Club of Philadelphia.* Vol. 1, No. 1, pp. 1–35. January, 1893, Philadelphia.—The first number of the new publication by the Geographical Club of Philadelphia contains an interesting and well illustrated paper upon Mountain Exploration by Edwin Swift Balch.

5. *The Mammals of Minnesota*, by C. L. HERRICK. Bulletin No. 7 of the Geological and Natural History Survey of Minnesota, N. H. WINCHELL, State Geologist. 300 pp. 8vo.—This work is a scientific and popular account of the features and habits of the Mammals of the State, illustrated by several plates and a number of woodcuts. The first of the plates is a fine colored figure of the *Geomys bursarius*, or Pocket Gopher. A second part of the work remains to be published devoted to the materials collected on the anatomy, especially the myology and osteology, of the State mammals.

6. *Ueber die Entwickelung der Theerfarben-Industrie* von Dr. HEINRICH CARO. 151 pp. Berlin, 1893 (R. Friedländer & Sohn). The *Deutsche Chemische Gesellschaft* has recently issued in pamphlet form the interesting and exhaustive lecture upon the aniline colors derived from coal tar, delivered before the Society by Dr. Caro on the 22d of June, 1891.

Annuaire Géologique Universelle: Revue de Géologie et Paléontologie, by Dr. L. Carez and H. Douvillé. The 4th fascicle of volume viii, year 1891, has been issued.

Geological and Solar Climates: Their Causes and Variations: A Thesis; by Marsden Manson, C.E., University of California. 49 pp., 12mo, May, 1893.

APPENDIX.

ART. XLV.—*Restoration of Coryphodon;* by O. C. MARSH. (With Plates V and VI.)

THE genus *Coryphodon*, established by Owen in 1846, is of great importance alike to geologists and paleontologists. It represents a remarkable group of large ungulate mammals now known to have lived both in America and Europe during early Eocene time. The remains are found in a distinct horizon, essentially the same in each continent. This horizon is so well marked that geologists may use it as a base for determining the age of other strata. The coryphodont mammals themselves are of special interest to anatomists, owing to the primitive characters shown in the skeleton. Perhaps their greatest importance lies in the fact, that these large hoofed mammals make their appearance suddenly in great numbers at the base of the Tertiary, without a hint as to their ancestral line, and with only diminutive generalized forms for their Mesozoic predecessors.

In Europe, various coryphodont remains, especially teeth, have been known under various names since the time of Cuvier, the first specimen, a molar tooth, having been found in 1807. All the remains since discovered there have likewise been fragmentary, and descriptions of them will be found in the works of Owen, Hébert, de Blainville, and more recent authors. A summary of the literature is given in the Palæontology of von Zittel, Volume IV, now in press.

The first specimen of *Coryphodon* discovered in America was found in 1871, near Evanston, Wyoming, by William Cleburne, while engaged as surveyor for the Union Pacific Railroad. He secured various remains, chiefly teeth and vertebræ, which were found together, and apparently belonged to a single individual. Some of these specimens he gave the same year to Prof. F. V. Hayden for transmission to Dr. Joseph Leidy, who failed to receive them. They were subsequently described by Prof. E D. Cope under the new generic names *Bathmodon* and *Loxolophodon*.* Portions of the same skeleton, including both teeth and vertebræ, were later given to the writer by Mr. Cleburne, and with them the above statement of the discovery and disposition of the specimens found. Prof. Cope, in 1872, gave the name *Metalophodon* to a specimen from another locality in Wyoming, and subsequently (1873–1875), in several papers, and under the above generic names, described various remains from Wyoming and New Mexico. He also gave figures of a molar tooth, the hind foot, and a skull, all of which he referred to his genus *Bathmodon*.

* Proc. Amer. Philos. Soc., vol. xii, pp. 417 and 420, 1872.

In the meantime, the writer had been investigating remains of the same group from Wyoming and New Mexico, including portions of the original specimen found by Mr. Cleburne, and other material of much interest. It was soon ascertained (1) that all these remains were apparently identical with those of the genus *Coryphodon*, Owen, as described and figured by him and Hébert;* and (2) that the geological horizon of these fossils was essentially the same both in America and Europe. An investigation was made of the skull, and especially of its brain-cavity, the latter indicating a brain of very inferior type. The feet proved to be of a primitive form, the manus and pes each having five, very short, functional digits. The remains studied belonged to a new family, named by the writer the *Coryphodontidæ*. These and other results were brought together in a paper entitled "On some Characters of the genus *Coryphodon*, Owen," and in it were given figures of the skull and the brain-cavity of a new species, *Coryphodon hamatus*. This paper was published separately, April 15, 1876, and subsequently appeared in this Journal, vol. xi, p. 425, May, 1876.

Subsequent to the publication of these determinations by the writer, Prof. Cope admitted, in several papers, the reference of these remains to the genus *Coryphodon*, and the identity of the horizons in this country and Europe in which they were found, but without referring to the above article on the subject. He likewise described in detail, and figured, in 1877, what he considered a brain-cast of *Coryphodon*, but again without any reference to the paper in which, the year before, the writer had given accurate figures of the brain-cast of that genus. In the specimen described by Prof. Cope, the cribriform plates of the brain-case were apparently wanting, so that in the cast figured the olfactory lobes appear to extend far forward, thus giving a wrong idea of the original brain.†

In the same year, 1877, the writer published a second article under the title, "Principal Characters of the *Coryphodontidæ*," in which he gave more in detail a description of the skull and brain-cast of *Coryphodon*, with a figure, and also the main facts in regard to the skeleton. The feet of this genus, before practically unknown, were described and figured, and especially compared with those of *Dinoceras*, which were also represented for comparison.‡ In Plate V of the present article, the original figures of the feet of *Coryphodon*, as given by the writer in 1877, are repeated. The original figure, also, of the

* British Fossil Mammals and Birds, p. 299, 1846; and Annales des Sciences Naturelles, tome vi, p. 87, 1856.

† Proc. Amer. Philos. Soc., vol. xvi, p. 616, plates i–ii, 1877. See also Amer. Naturalist, vol. xi, p. 312, and p. 375, 1877.

‡ This Journal, vol. xiv, p. 81, plate iv, July, 1877.

skull and the brain-cast, given by the writer first in 1876, and again in 1877, is repeated below, figure 1.

In another publication (this Journal, vol. xiv, p. 354, 1877), the writer defined more fully the horizon in the lower Eocene in which the *Coryphodontidæ* had been found in this country, and named the deposits the Coryphodon beds.

1.

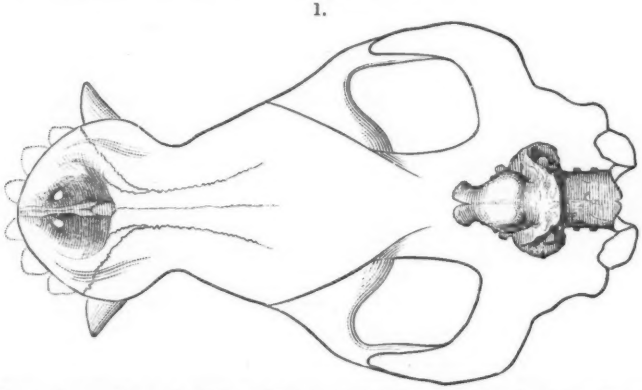


Figure 1.—Outline of skull and brain-cavity of *Coryphodon hamatus*, Marsh; top view. About one-fifth natural size.

The most important publication of Prof. Cope on the *Coryphodontidæ* will be found in Volume IV of the Wheeler Survey, published in 1877. The remains of a number of different forms, mainly from New Mexico, are described and figured, and the relations of the group to some allied mammals are discussed. In the following year, Prof. Owen published again on *Coryphodon*, in the Annals and Magazine of Natural History (vol. ii, p. 216, 1878), giving figures of some American forms. In various papers, Prof. Cope subsequently referred to the *Coryphodontidæ*, naming several supposed species and two genera, *Manteodon* and *Ectacodon*, but adding little of importance to what was already known of the group. In his volume on "The Vertebrata of the Tertiary Formations of the West," 1884, he again discusses at length the *Coryphodontidæ*, and gives a number of new figures. The historical part, pp. 513–517, is marred by many errors, characteristic examples of which may be seen in two footnotes, pp. 513 and 516. The statements there made are erroneous, as has already been shown in the present article.

In his monograph on the *Dinocerata*, 1884, the writer discussed the various relations of the *Coryphodontidæ* to the *Dinocerata*, giving figures of the skull and brain-cast, the upper and lower molar teeth, and the feet, of *Coryphodon hamatus*. The name *Amblydactyla* was substituted for *Amblypoda*, and *Coryphodontia* for *Pantodonta*, the names replaced both being essentially preoccupied.

Two recent papers by Mr. Charles Earle, on the *Coryphodontidæ*, are of interest.* He treats of the teeth of this group, especially of their variations and homologies, and gives figures of some of the most characteristic forms. He also discusses at length the various American species named, and decides "that the large number of species which have been founded by Prof. Cope should be greatly reduced; and that in many cases his species are to be considered merely varieties, and that often these varieties are merely individual variations in the same species due to age and sex."

In a joint paper by Prof. H. F. Osborn and Dr. J. L. Wortman, which appears in the Bulletin of the American Museum, p. 81, 1892, the former discusses this group briefly, especially some specimens recently collected in the Wind River region by Dr. Wortman, and gives two figures of the feet of *Coryphodon*. In this paper, p. 118, the family *Coryphodontidæ*, established by the writer in 1876, is credited to Prof. Cope, but with no reference as authority, while the preoccupied names *Pantodonta* and *Amblypoda* are also used in place of *Coryphodontia* and *Amblydactyla*.

In discussing the foot structure of *Coryphodon* (p. 121), Prof. Osborn makes some very emphatic statements, which are important if true, but he gives no facts to support them, and there is good evidence that he is in error. One statement is as follows: "the positions of the fore and hind feet of *Coryphodon* were absolutely different, the *fore foot was digitigrade* like that of the Elephant, and the *hind foot was plantigrade* like that of the Bear." These positions are shown in his figures, which afford no evidence to support the statement, especially in regard to the hind foot. Again, in giving the characters of the feet, Prof. Osborn adds to what was already known, that the "second metacarpal" has a vertical ectocuneiform facet; a statement likewise open to question. Another assertion (p. 122) nearly as strange is, that in "The figure of the pes of *Coryphodon* given by Marsh . . . . . the astragalus is represented as *covering the entire upper surface of the cuboid*." A reference to the figure in question (Plate V, fig. 2) will, however, show this statement, also, to be wrong, as the calcaneum covers about half the cuboid. This fact was clearly stated in the text when the figure was first published. The "unique caudal appendage" described by Prof. Osborn (p. 120), and the suggestion in regard to its use, do not require special notice here. The above points will be discussed later in the present article.

*Science, vol. xx, p. 7, 1892; and Bull. Amer. Mus., vol. iv, p. 149, 1892.

Restoration of Coryphodon hamatus.

After the above brief review of the more important literature relating to the coryphodont mammals found in America, the main object of the present article, the restoration of one species of *Coryphodon*, may be considered. In Plate VI, this restoration is given, one-twelfth natural size. The position shown was chosen after careful consideration, and is believed to represent fairly one naturally assumed by the animal in life, when standing at rest. The figure represents a fully adult individual of one of the largest species of the genus, which, when alive, was nearly six feet in length, and about three feet in height.

The basis of this restoration is the type specimen of *Coryphodon hamatus*, and this was supplemented by other remains which appeared to be specifically identical. A large number of such specimens were available, some of them in excellent preservation. For parts of the skeleton where such remains were wanting, specimens from nearly allied forms were used, but no serious error can thus result. In these remains, the caudal vertebræ were seldom preserved in good condition, and although a sufficient number of such specimens from different individuals were at hand, the exact number in the present species could not be determined, and hence the vertebræ of the tail are left in outline.

No clavicles are represented in the restoration, and no evidence of their existence has been found by the writer in the many remains investigated. The specimens described by Prof. Cope as clavicles of *Coryphodon* probably do not pertain to that genus. A bone very similar in shape to the supposed clavicles was figured by him as the fifth metatarsal, in the first diagram he published of the hind foot of *Coryphodon*. The same figure has three phalanges in the first digit, and the ecto-cuneiform supported mainly by the astragalus; features not seen elsewhere by the writer.

The feet of Coryphodon.

The structure and position of the feet of *Coryphodon*, as represented in the restoration, require some consideration in this connection, in view of differing opinions on these points. The fore feet of *Coryphodon* were first figured and described by the writer, and on Plate V, figure 1, is the original cut then published. This figure was made from a well-preserved specimen in which both fore feet were present, and nearly in position when found. They were carefully kept in the matrix until prepared for the drawing, and hence the accuracy of the figure cannot well be questioned. The fore feet represented

in the present restoration are constructed mainly from the same specimen, and the position given in the original figure has been essentially retained. The small size of the restoration does not permit as accurate an exhibition of the structure of the feet as could be desired, but the main features are clearly shown. In this species, the pyramidal bone (cuneiform) touches the fifth metacarpal, and helps to support it, as in *Dinoceras*, as already shown by the writer. This is the rule in adult individuals of *Coryphodon*, but in young specimens, the metacarpal facet on the pyramidal may be indistinct or even wanting, as is sometimes the case with weathered specimens.

The hind feet of *Coryphodon* were investigated by the writer at the same time as the fore feet, and figure 2, Plate V, of the left pes was published with figure 1, and is believed to be equally accurate. Being a front view, it does not fully show the relations to each other of the astragalus, calcaneum, and cuboid, but the other elements are clearly exhibited. The position first given to the figure is retained in the restoration after a careful investigation of the whole posterior limbs in a number of well-preserved specimens. These differ considerably among themselves, but the essential structure is identical in all. The feet bones of some of these specimens are very perfect, and their relations to each other cannot well be misinterpreted.

The accompanying Plate V gives together the left fore and hind feet of *Coryphodon*, *Dinoceras*, and *Elephas*, all seen from in front. The feet of the three genera as exhibited have many points in common, and their positions during life were probably nearly the same. The feet of *Coryphodon* are the oldest in point of time, but those of the elephant are in some respects of a more primitive type. Those of *Dinoceras* are much nearer to *Coryphodon* in their general structure, but the points of resemblance need not be enumerated here. The elephant, as well known, has all the toes of each foot enclosed in a common integument, but is really digitigrade. In *Dinoceras*, the terminal phalanges are much larger, showing that they themselves bore a greater weight, the digits being undoubtedly free, although a pad may have helped to support the foot. In *Coryphodon*, the digits were still more elongate, and the terminal phalanges proportionately larger and broader, somewhat like those of the rhinoceros, indicating that they were covered with hoofs that supported the feet. This would agree with the position given them in the restoration, which coincides with the anatomical structure of the entire hind limb.

Yale University, New Haven, Conn., September 22, 1893.

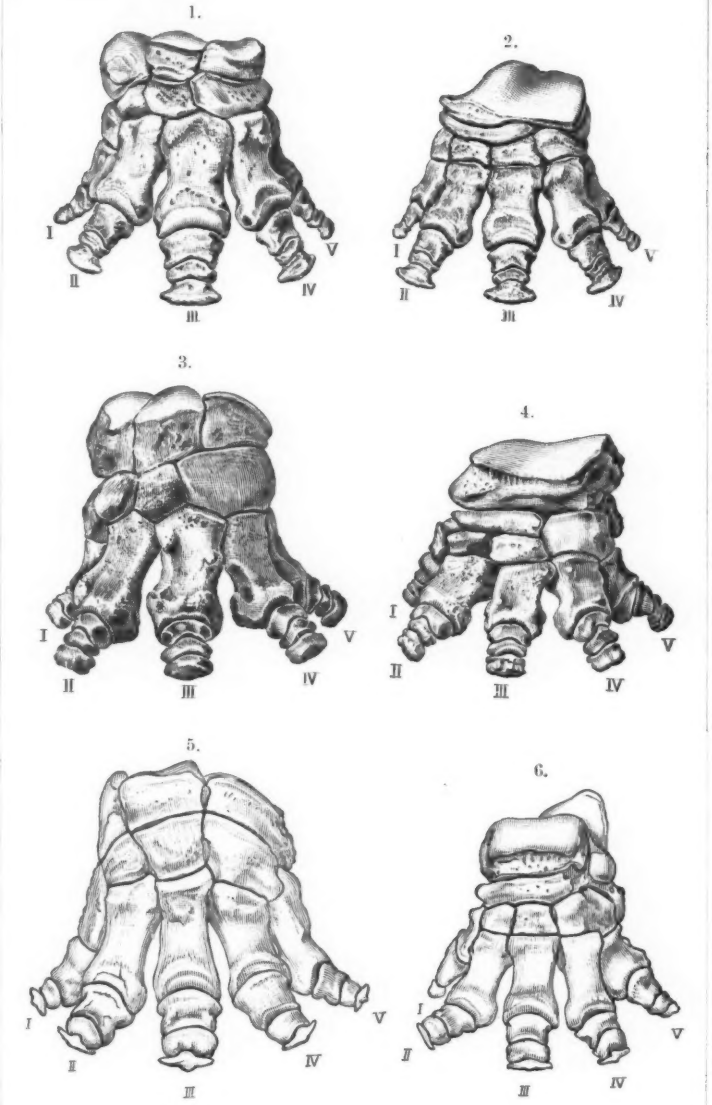
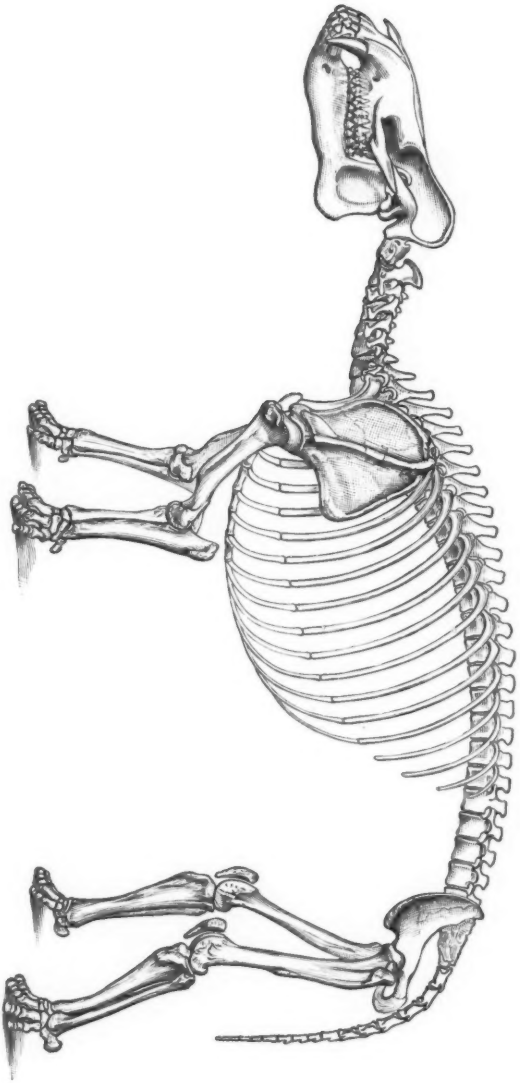


FIGURE 1.—Fore foot of *Coryphodon;* front view.
FIGURE 2.—Hind foot of *Coryphodon;* front view. Both one-third natural size.
FIGURE 3.—Fore foot of *Dinoceras;* front view.
FIGURE 4.—Hind foot of *Dinoceras;* front view. Both one-fifth natural size.
FIGURE 5.—Fore foot of *Elephas;* front view.
FIGURE 6.—Hind foot of *Elephas;* front view. Both one-eighth natural size.



Restoration of CORYPHODON HAMATUS, Marsh. One-twelfth natural size.

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